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U.S. METRIC STUDY INTERIM REPORT

DEPARTMENT OF DEFENSE

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SP 345-9

U.S. METRIC SUBSTUDY REPORTS

The results of substudies of the U.S. Metric Study, while being evaluated for the preparation of a comprehensive report to the Congress, are being published in the interim as a series of NBS Special Publications. The titles of the individual reports are listed below.

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U.S. METRIC STUDY INTERIM REPORT

DEPARTMENT OF DEFENSE

Ninth in a series of reports prepared for the Congress

U.S. METRIC STUDY
Daniel V. De Simone, Director

U.S. National Bureau of Standards
Special Publication 345–9

UNITED STATES DEPARTMENT OF COMMERCE
MAURICE H. STANS, *Secretary*
NATIONAL BUREAU OF STANDARDS
LEWIS M. BRANSCOMB, *Director*

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LETTER OF TRANSMITTAL

THE HONORABLE PRESIDENT OF THE SENATE
THE HONORABLE SPEAKER OF THE HOUSE OF REPRESENTATIVES

SIRS:

I am presenting to you the ninth in the series of interim reports concerning various aspects of the U.S. Metric Study. This report was prepared by the Department of Defense and represents its independent estimate of the economic costs that it would experience in a coordinated national changeover to the metric system.

This contribution to the U.S. Metric Study, along with all of the others that have been received, is being evaluated. All of these contributions are therefore published without prejudice to my comprehensive report to you on the entire U.S. Metric Study, which will be made in August of 1971 and will reflect this evaluation.

Respectfully submitted,

Secretary of Commerce

LETTER OF TRANSMITTAL

Honorable Maurice H. Stans
Secretary of Commerce

Dear Mr. Secretary:

The attached report outlines the findings of our analysis of the impact of increased use of the metric system on the Department of Defense. It is provided in support of the U.S. Metric Study assigned to your Department by the 90th Congress under Public Law 90-472.

The Department of Defense recognizes that any decision to go metric is a National one and we have not taken a position either for or against such conversion. It is noted, however, that directed conversion would have an impact on budget and operational considerations within the Department of Defense. This is particularly noteworthy during the current period of fiscal constraints when the limited funds available must be applied to the most urgent needs of National security.

We will, of course, cooperate in any recommendation that you may make to the Congress and in the implementation of any program that may result from Congressional action.

If conversion is directed, I would like to call attention to the need for a national schedule for metrication and the establishment of priorities for all phases of conversion to minimize the impact on our defense posture during the transition period. Close coordination between the Defense Department and the responsible metric conversion agency will be essential.

I trust that this report will satisfy your needs for an appropriate response to the Congress. If we can be of further assistance, please let me know.

Sincerely,

Melvin R. Laird
Secretary of Defense

INTRODUCTION

1. Public Law 90-472, enacted 9 August 1968, authorized the Secretary of Commerce to conduct a study to determine the impact of increasing worldwide use of the metric system on the United States; to determine the desirability and practicability of increasing the use of metric weights and measures in the United States; to study the feasibility of retaining and promoting international use of dimensional and other engineering standards based on customary measurement units of the United States; and to estimate costs and benefits of alternate courses of action which may be feasible for the United States.

2. DEPSECDEF Memo of 27 September 1968 assigned to the Air Force the responsibility for leading the study within the Department of Defense(DOD).

3. ASST SEC AIR FORCE (INSTALLATIONS & LOGISTICS) MEMO OF 3 January 1969 established a DOD Metric System Study Steering Committee under the chairmanship of the Air Force, with members from the various components and services of the DOD. The steering committee developed basic assumptions and guidelines for formulation of DOD input.

4. ASST SEC AIR FORCE (INSTALLATIONS & LOGISTICS) MEMO OF 16 October 1969 transmitted study guidelines and requested that major components of the DOD analyze their own activities to measure the advantages, disadvantages and impact of increasing worldwide use of the metric system.* Results were to be reported along with information on the cost that would be incurred in maintaining constant mission capability under a ten-year cycle of metrication in the event of a national change to the metric system. The Air Force memo recognized that no funds could be made available for the study, and therefore, recommended that a minimal effort be expended consistent with development of a competent position.

5. ASST SEC AIR FORCE (INSTALLATIONS & LOGISTICS) MEMO OF 7 January 1970 further defined the scope of the study.

6. STUDY PARTICIPANTS. Over 125 elements of the Joint Chiefs of Staff, Army, Navy, Air Force, Defense Supply Agency, National Security Agency, and other DOD agencies participated in the DOD study. About fifty representatives of various DOD elements were organized into nine subcommittees, e.g., Operations, Logistics, Research/Development, Construction, Personnel and Training, Legal, and Financial. These subcommittees worked on a full-time basis for several months and prepared the study assumptions and guidelines. The DOD Steering Committee, with representation from the DOD activities, monitored the DOD-wide effort and evaluated all inputs to produce this report.

*Systeme International d'Unités (abbreviated "SI") as described by U.S. Department of Commerce, Bureau of Standards, Handbook 102, issued 10 March 1967. (Superseded by ASTM Standard Metric Practice Guide, available from American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.)

NOTE: The above mentioned Public Law, memos and guidelines appear in Appendix A.

ACKNOWLEDGMENTS

Appreciation is expressed to the representatives of each of the more than 125 Field and Command elements of the Department of Defense who provided the basic inputs to this study.

Special acknowledgment for their continued assistance and support is due each of the following members of the Department of Defense Steering Committee:
Capt. R. F. Dunbar, USN, Office of Joint Chiefs of Staff
Mr. Jack L. Vogt, Army
Mr. Winton E. Allen, Navy
Dr. Joseph L. Krieger, Air Force
Mr. James Brownell, Defense Supply Agency

In addition, the professional assistance of several staff members deserves special acknowledgment:
Mr. H. J. Dickinson, Navy
Lt Col H. G. Tinsley, Air Force
Mr. A. P. Babbitt, Air Force
Mr. F. L. Ellison, Air Force

Great appreciation is also expressed to the retired former chairman of the Department of Defense Metric Study, Mr. Vincent S. Roddy, for his dedicated effort in the early phases of the study.

Leighton Lomas, Chairman
Department of Defense Metric Study

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I. PURPOSE OF STUDY

To determine and evaluate the impact on operational capability, advantages and disadvantages, and costs of adopting the International System of Units (SI) of weights and measures for use in the Department of Defense (DOD).

II. ASSUMPTIONS

In order to provide a basis from which to evaluate the impact of metrication upon the DOD it was necessary to establish a set of assumptions relative to the metric system, conversion period, force structure, and industrial conversion process. The results of any evaluation of the metrication process are highly sensitive to these assumptions. The assumptions made for the study are contained in Appendix B. In evaluating the study findings, the differences between the scenario established by the study assumptions and the prevailing situation (e.g., reduced budget and force cuts, with accompanying operational risk) must be considered.

III. SUMMARY

A. If conversion to the metric system is directed, the DOD transition will have a significant impact on mission capability unless sufficient additional resources are made available for the total task and a national conversion schedule is adhered to by industry. The DOD is dependent upon the National Industrial Base, and the rate of conversion within the DOD will depend largely on how well conversion is carried out by industry. Industry must take the lead in any such conversion. DOD must not be placed in the lead role and thereby find itself in the position of forcing the country to convert to metric units by writing contracts with metric requirements before industry has sufficiently converted. If DOD is placed in the lead role, the cost to DOD and the resultant decrease in Defense capability will greatly exceed the estimates, dollar and otherwise, contained in this report.

B. Based on the assumptions of the study, the total additional funds for computed costs that will have to be made available for transit to the use of the metric system are estimated to be approximately $18 billion, and are such that they cannot be absorbed within the DOD budget without deterioration of the military posture. Costs not computed in the study will increase this amount.

C. During the period of transition there will be no major advantages to the DOD and major disadvantages will occur. This is the period wherein the greatest costs will occur; psychological resistance to change will be greatest; extensive training and retraining of personnel must be undertaken; conversions will increase operational hazards; dual stockage and dual manufacturing capability will be required in certain instances; material and system acquisition and conversion will create forces with mixed equipment; and development of metric standards will be necessary.

D. The conversion of the country to the metric system could adversely impact on the ability of the United States to support its military forces during the proposed transition period. Without proper planning and adequate funding, the reduced flexibility and capacity of the support available would impact upon the capability of the Armed Forces to perform their mission, especially if an international crisis should develop at critical times during this period requiring the employment of major forces in a combat role.

E. The military advantages expected following transition are the day-to-day use of an inherently simpler system and the compatibility of U.S. and foreign equipment. Although the use of a simpler system would have no outstanding military advantage, the slight

advantage expected would be amplified because of its widespread nature. The compatibility of U.S. and foreign equipment will enhance combined military operations and simplify logistics support requirements. The completion of metrication will leave some long-term disadvantages. These will occur in the logistics area and deal with long-life items which will remain in inventory well after the programmed metrication cycle has been completed. When these long-life items are removed from the inventory, the advantage of a single world-wide standard system of measurement will facilitate combined operations and logistics support among allied armed forces.

F. Should metrication be directed, a full-time and continuing staff within DOD will be required to prepare a detailed implementation plan, including contingency plans; and to implement and administer the metric system plan as appropriate.

IV. MAJOR FINDINGS

A. Added Cost to Maintain Constant Mission Capability.

1. The added cost to maintain constant mission capability while converting to the metric system is estimated to be approximately $18 billion. The major financial impacts of converting to metric measurements will involve additive costs associated with the areas of design, development, procurement and support of new systems, publication of technical data, training of personnel, and storage generated by metrication. Such additive costs were computed or estimated by the major DOD agencies (see Appendix C). Each agency's estimate was derived independently and is based upon individual interpretations of the assumptions and guidelines. It must also be emphasized that the estimates were based on many variable factors, some of which are outside the purview of DOD control. The sum of the agencies' costs provides the best estimate of the total cost to DOD for metrication. Table 1 summarizes these costs.

TABLE 1

DOD Cost of Metrication
(Millions of Dollars)

Army	4,353
Navy	7,083
Air Force	6,354
Defense Supply Agency (DSA)	218
Defense Intelligence Agency (DIA)	*
National Security Agency (NSA)	*
Defense Atomic Support Agency (DASA)	*
Defense Communications Agency (DCA)	*

2. Above costs are conservative, since several cost considerations were specifically omitted in order to establish a uniform cost base.

a. The assumption was made that components would be available in either system as required at no cost penalty. This assumption is not entirely realistic because the availability of metric components early in the changeover and the availability of customary components later on undoubtedly will be limited. This supply shortage most likely will dictate a premium price, over and above add on costs associated with normal business amortization of "metric start-up" costs. However, until a master plan for metrication is adopted, and the interrelationships caused by the implementation of the plan are known, this factor cannot be evaluated or costed with any degree of accuracy.

* Cost Impact Negligible in Terms of Costs Shown

b. The costs were developed as percentages of the FY 70 President's Budget and thus are in 1970 dollars; no inflation factor is applied.

c. The cost estimates contained herein do not include increased cost of "off-the-shelf" type items/equipments. The guidelines for the DOD Study stated that the Department of Commerce will project such costs. Those costs could be significant and represent a general surcharge applied by the manufacturers to their complete lines of products to retrieve the overhead-type costs encountered in their engineering departments and machine shops for changeover to the metric system. Such a surcharge (the extent of which is unknown at this time) would undoubtedly be borne by the DOD and therefore represents an additive budget requirement.

d. The cost attached to mistakes made by operating personnel due to "metric mix-ups" was not estimated. For example, a mechanic picks up the wrong type of bolt and ruins a part in his attempt to force it to fit. It would be less than realistic to presume that the change to metric parts will not open up a whole new spectrum of such mistakes. Training and operating commands have recognized this error potential in their assessment of the metric impact. They must do all that is physically possible to pinpoint and minimize the chance for such errors but they will never be able to completely eliminate them.

3. Anticipated changes in force structure will not appreciably reduce the estimated dollar cost of metrication. The significant identifiable costs of conversion are in the support areas, namely in physical plant, production, equipments, and tools; modification of equipment and systems supply support in terms of specifications or standards, stock numbers, catalogs, maintenance manuals, maintenance of expanded inventories, and related identification data. Because these are one time costs, reduction in force units will have little effect on support and/or conversion of equipment or systems costs unless the equipment or system is eliminated completely from the Service-wide inventory without replacement. On the other hand, a reduced force structure, which results in reduced civilian and military personnel to perform the conversion job, means that the conversion task would either have to be stretched out or the dollar cost will increase.

B. Operational Considerations.

1. The metrication process will impact upon the operational capability of the military forces. For example:

a. Computer programs for data systems will have to be revised. Tactical data systems will require simultaneous conversion of all units operating as an offensive or defensive entity if they are to retain their usefulness. Present gun and missile fire control computers are of the analog type, except for some very recent systems, which are digital. Analog synchro data transmission systems are used with the analog computers. There is no simple and inexpensive method for converting analog fire control systems to SI units.

b. Installed equipments, supporting equipments, and documentation for operational systems will require appropriate changes or modifications.

c. Communications procedures pertaining to weather, navigation, and takeoff/landing instructions will have to be revised to accommodate the change.

d. Observations and weather reports will have to be changed to reflect metric measure for ceilings, visibilities, altitudes, and windspeeds.

2. Complicated weapons systems involve numerous components which must fit together into a workable system through the systems engineering process. The interfacing of equipments/components designed in the inch-pound and metric systems will present a challenging task. If the cost and time delays are to be held to a minimum, an effective decision-making system must be developed to determine the when and how of conversion on each system. Trade-off studies will be required to determine the degree of mix which can be tolerated in the engineering support and operational areas. Metrication of new equipment designs can proceed on an orderly basis only if there is a phased national schedule for the conversion of each major segment of American industry. In order to minimize the impact of continued use of mixed (inch-pound metric) systems in any area, full cooperation between the Government and industry in meeting conversion schedules will be vital.

3. Operational capabilities and readiness will be decreased during the transitional period due to confusion associated with having to operate and maintain systems/equipments built to either one measurement system or the other or both. This condition will persist until complete conversion is effected and all customary and mixed systems/equipments are phased out of the inventory.

4. Some manpower engaged in productive occupations will have to be removed from such occupations and placed in planning and training. Few personnel, even engineers and scientists who are well versed in metric units, have the intuitive understanding or "feel" for metric sizes that they have for inch-pound sizes. Lead times for development, design, procurement, production, installation, and operations will be increased due to the inefficiency of personnel resulting from their lack of familiarity with the SI system of measurements. For the same reason, additional time will be required to perform maintenance which, in turn, will further detract from the operational capability. The cost of new weapons/equipments development will also be higher due to the fact that industry will be experiencing the same inefficiency.

5. Depot maintenance operations will require more time during the transition period. In addition, field maintenance organizations must solve the problem of transporting the extra equipment and material which the metrication process will impose. The maintenance section of an armored cavalry squadron, for example, currently has a prescribed load list (PLL) of 466 items. When the squadron goes to the field, the maintenance section must carry the PLL plus all of its other equipment and tools in organic transportation. This transport is already overcrowded and the addition of 25-50% more to the PLL due to dual part stockage and dual tool sets will further compound this problem.

6. Metrication will, in the early phases, result in considerable confusion when attempting to secure quotations for supply, services, and equipment. Additional management effort will be required specifically for planning and phasing the production and procurement of metric components. There will be some increase in acquisition and development time, primarily due to gathering metric information, and preparing drawings with metric or dual dimensions. Further, there will be a requirement for revised and/or dual specifications, a need to update technical documentation and an increase in the number of engineering changes. The procurement of off-the-shelf bits and pieces will pose a special conversion problem.*

* See Appendix E

7. Metalworking equipment (machine tools) for the most part has a long life span. The DOD has 144,122 machine tools in the DOD Industrial Plant Equipment Center (DIPEC) inventory which had an original cost of approximately $2.4 billion. Modification of this inventory will cost approximately $115 million.*

8. There are customary standards that could and should be retained: those now having wide international acceptance, and those military standards which are necessary to support existing equipments.**

9. The transportation of cargo is based on conventional measurements. Palletization, containerization, and standard loading systems are all interfaced and must be maintained compatible. Further, the air cargo operation directly interfaces with surface systems and compatibility must also be maintained.

C. Practical Difficulties and Suggested Means of Minimizing Them. A number of practical difficulties are expected to arise if conversion to the metric system is directed. Some are significant because of the cost impact and some because of the psychological impact. The practical difficulties expected to have the greatest impact along with suggested means of minimizing them are:

1. At this time it is difficult to judge what cost industry will pass along to DOD as a system cost due to metrication. However, since each contract is awarded individually, much of the cost of conversion to produce the new weapon system in metric units will include industry's cost. This is especially true if the industry involved is primarily or solely in the defense business, which means that its customer base is very narrow. The defense contractor has a practical difficulty in attempting to estimate future contract awards and will be inclined to write off the costs due to metrication as they occur. Contracting officers awareness of this problem during contract negotiations should minimize the impact. ***

2. Some delays in the systems development and acquisition process can be anticipated due to metrication. For the purposes of this study, a straight line 10-year conversion was assumed. However, the national industrial base will convert in the manner that is most economical for a particular sector of industry. The larger industries can plan their conversion on the requirements of their customers and also on the materials furnished by their suppliers. For example, the auto industry is large enough to effect an orderly conversion. The customer for automobiles and trucks would have minimum effect on how the industry converted as long as costs were held to a minimum and replacement parts and repair capability were not impaired. Most important, the auto industry buys such large quantities of materials, it could dictate to the supplier the system of measurements that must be used. Thus, steel would be rolled in millimeters and bar stock provided in standard SI units along with metric fasteners when the auto industry desired. Smaller businesses like the fastener industry are not able to plan in isolation from their customers' needs or suppliers' conversion schedule. The fastener industry cannot economically produce large quantities of metric fasteners until their customers want them in metric units. On the other hand, the fastener industry is not a large purchaser of steel and cannot dictate to the steel industry as to the time when metric bar stock becomes the normal and inch bar stock the special order. Further, in the fastener industry, machine

* See Appendix C (DSA)
** See Appendix H
*** See Appendix F for Legal Aspects

tools cannot be used until obsolete, but must be converted for metric production equipment when their customers elect to convert and their supplier will furnish the required materials. This interplay within industry and the dependency of each industry on both customer and supplier will affect the DOD rate of conversion and cost. Therefore, the development and procurement function in the DOD must be closely attuned to the industrial conversion so that unnecessary premature attempts are not made to force production of metric modules.

3. Air traffic control terminology and procedures are areas where international cooperation and coordinated planning is imperative. Since most airway structures and flight procedures are based on customary units, a change to the metric system will require a concerted international effort to effect an orderly, safe conversion. Therefore, if the decision to convert is made, affected equipment will have to be replaced or modified and all air traffic controllers and pilots thoroughly schooled in the new system before it is implemented. The fact that air traffic controllers are familiar with metric units is not suitable evidence of their ability to perform in an emergency situation, nor does this necessarily reflect an intuitive understanding of metric units. The Federal Aviation Authority must coordinate all conversions involving changes to air traffic standards, procedures, and equipment to minimize flying safety hazards.

4. During the 10-year metrication cycle, all manuals, regulations, technical orders, monitors, readouts, meters, maps, blueprints, plans, plant-in-place records, drawings, and other publications, specifications, and instruments will have to be inspected and changes made on an as required basis. Therefore, all publications, specifications, and instruments will have to be inspected on an individual basis to determine what action will be required to make them compatible with metrication. Revisions, changes, or modifications required must then be specified and plans made to phase in these requirements. Existing publications will have to be updated, while new ones will be required to utilize metric standards (perhaps with optional listing of common standards). It will probably be necessary to utilize maps, charts, blueprints, etc., which reflect both inch-pound and metric units during the metrication-transition cycle. Although these will be complicated to use because of decreased legibility and increased congestion of information, they will be necessary in order to make the transition.

5. In the conversion of standards, the use of metric units of measurement introduces no difficulties in itself, since the relationship of the inch to the millimeter is constant. However, the same consistency does not apply to the standards of drawing practice, design, utility components, etc. There is a wide variation among the practices of the European metric nations. The U.S. must avoid the situation where drawings are prepared to a variety of domestic industry or national customs and practices. It is essential that the metric standards and practices that the U. S. adopts are accepted on the widest possible international basis. The Department of Defense Index of Specifications and Standards lists some 40,000 documents. Some of these documents will be retained in their present form to support existing systems. Many of the documents will require changes because of metrication. To effect an orderly conversion, good metric standards must exist as a basis for conversion. Metric standards must be developed that are as good or better than existing standards if the quality of manufactured items is to equal or exceed the quality of items manufactured using customary units.* New standards are usually developed in this country on a voluntary basis. The industrial associations are the biggest supporters of this voluntary program. To assure that good metric standards are available when needed, a streamlined method of developing metric standards needs to be implemented. In addition,

* See Appendix E

all Agencies of the Federal Government, in unison, must fully support the development of new standards. Steps must be taken to assure that a bottleneck does not develop either in industry or the Federal Government. The availability of standards, specifications, material, mensuration and manufacturing equipment in metric terms early in the 1972 to 1977 period will be necessary to meet the 1982 programmed date for mandatory production in SI units. Careful planning and establishing priorities at the DOD and industry level and coordination and rapid dissemination of information at all organizational levels will be a must to minimize delays and avoid confusion.

6. Conversion of the aircraft industry is expected to be particularly difficult. Prior studies indicate the majority of the aircraft and aircraft engines operating around the world are built with components using the inch-pound system. Furthermore, many aircraft have a useful life considerably longer than 10 years. Therefore, widely accepted standards such as the unified screw thread should be retained until a metric standard equally as good or preferably better is developed. If the aircraft industry adopts full metrication, it may be necessary to stock both metric and inch-pound sizes of many aircraft parts for very long periods of time unless some of these common items can be continued in production with the present sizes even though they are identified by two different dimensional units.

7. Overhaul and maintenance time will be increased due to the need to service dual systems. There will also be an increased need for supervision as well as added effort to maintain currency in drawings, manuals, and procedures. The principal means of reducing or preventing an increase in overhaul or maintenance time is adequate implementation of the conversion program. This means that there must be adequate training, ample use of conversion tables, dual scales where appropriate, timely revision of manuals, specifications and drawings, and adequate attention by the supervisors to the problems involved.

8. During transition and for some years beyond the conversion completion date of 1982, the DOD must retain a capability in both inch-pounds and metric. Even though new developments and acquisitions will be in metric units, existing systems will be used beyond the conversion period. For example, the weapons stockpiles, nuclear as well as conventional, may include many items which will be retained longer than the 10-year transition period. Further, the test ranges and laboratories must retain gauging and test equipment to support inch-pound modules. Technical documentation will continue to be published in the customary units for existing systems. Some new developments that are to be used with existing equipment will necessarily be designed to interface with the equipment in the inventory. Standard items such as steel rods and bars, sheet steel, pipe, lumber, and fasteners (screws, bolts, etc.) will become difficult to obtain in inch-pound units. Procurement of spare parts for items manufactured to inch-pound standards may be impractical or expensive. In addition, new specifications and Federal Stock Numbers will have to be issued for metric parts. Therefore, if metrication is directed, all existing inventories must be used if possible, since they represent a large investment. Future procurements of items manufactured to metric standards will replace the older items and will require Federal Stock Number designations. Requirements for spare parts for older equipment will have to be evaluated on the basis of necessity and expense. If the item is critical, it may have to be specially made or the equipment may have to be modified to restore operations. Such instances will have to be evaluated on a case-by-case basis to determine the appropriate action required. Coordination with industry and increased management effort will be required to keep cost and waste to a minimum. Where dual inventories are required, storage space will have to be provided.

9. Additional warehouse space will be required for storage and issue of metric supplies during the conversion period. To meet this requirement, temporary warehouse space will have to be provided. This can be accomplished through minor modifications and alterations of other buildings at each field activity to provide a segregated storage location for the metric-sized parts and tools.

10. It is expected that some difficulty will be encountered in obtaining equipment to convert lathes, gear shapers and cutting machinery to the metric standard of pitches and leads. Measuring tools, gauges, taps, drills, reamers, etc., will need to be converted or replaced. This equipment is not currently available in the United States in sufficient quantities. It therefore will be necessary to stimulate interest in United States industry to develop such equipment. However, even then the government agencies will without doubt have to compete with industry for it. This situation will necessitate careful planning and early procurement in order to overcome these difficulties. The practical approach of a gradual changeover to metric tooling introduces its own problem of maintaining both inch-pound and metric items during the interval when there is a choice in design and machinery requirements. Many of the existing inch-pound tools and measuring devices will remain in the inventory until the inch-pound systems being supported are phased out of the active inventory.

11. Initially, there will be a large potential for error in converting data. Basic data conversion can be accomplished in several ways. Automatic data processing data can be converted by a computer program developed especially for the purpose of converting inch-pound units to metric units. Other basic data will necessitate manual conversion and will require additional personnel who must be closely supervised and their work adequately checked.

12. The longest life expectancies of existing nonmetric resources are probably represented by real property facilities. The entire physical plant of buildings, pavements, and similar structures was constructed from English systems components and is frequently expected to provide useful service for 50 or more years. Contained equipment (boilers, power plants, etc.) are a similar (but shorter duration) consideration. The ability to repair rather than completely replace is an economic necessity. However, the existing investments by manufacturers and property owners probably will be acknowledged by industry. Building material continuity will likely be provided initially by redesignation to metric sizes (lumber, pipe, blocks, bricks, steel, etc.) with an actual change to metric standards guided by the economic parameters of the industry.

13. Until personnel become sufficiently familiar with the metric equipment, mistakes in identification of tools and piece parts will be made. There will also be errors in equipment selection and adjustments. This problem will greatly affect the overall conversion process and must be endured as a natural consequence of conversion. Special markings on metric tools, bolts, nuts, screws, fasteners, etc., is one example of a way to minimize identification mistakes. Probably, it will be best to keep equipment originally made to the inch-pound measurement system unaltered during its useful life and not permit partial conversion to metric standards. This means that with the exception of attachments for portable equipment, all fixed machinery and fixed equipment in major systems built to inch-pound measurement should remain unmodified during the life of the system. To prevent confusion, and in the case of safety equipment, avert disaster, all fittings for attaching portable equipment on any one system should be changed simultaneously and mixtures of standards, such as two types of fire hose threads on one ship, must not be permitted. Each organizational unit should be instructed to review both its working procedures and its physical equipment and submit plans for altering or replacing equipment, instruments and tools. Each organizational unit should be required to state its plans for

additional checks and inspections for the detection and correction of errors generated in the changeover process. A high degree of alertness by supervisors and workers will be needed to minimize this problem.

14. A major difficulty during the transition will be overcoming the inertia in thinking and performance of the work force without benefit of prior formal training in metric studies or familiarity in use of metric standards. Another serious practical problem is the psychological difficulty of educating the trained individuals to think and operate in terms of metric units and yet retain their intuitive judgment which now enables them to mentally choose the correct wrench size, estimate lengths reasonably well, and to mentally visualize blueprint dimensions and stock sizes in an expeditious and efficient manner. Therefore, a formal training program, early in the conversion period, will be required to overcome psychological adjustments caused by "resistance to change" from the familiar inch-pound measurement system to the SI measurement system. There will be an effective reduction of manning within DOD agencies due to time required for training in the metric system. This reduction in effective manning because of the time required for training might be overcome by on-the-job training, and by adding training in the metric system to the other training programs. Increased surveillance and tighter management controls at all levels will be necessary to maintain training standards commensurate with metrication development. Course length and course content must be regulated as appropriate, and budgets and manpower authorizations must be adjusted to accommodate these changes. The immediate teaching of the metric system at all levels of public school beginning with the metrication cycle will ease the basic problem for the younger generation which will be entering the work force during and after metric conversion.

15. There is a general category of nuisance difficulties related to the inconveniences which will be experienced by personnel in the metric system conversion process. Elements of this category are:

a. Education necessary to become familiar with the SI system.

b. Adjustment to new scales, gauges, measuring terminology, etc., associated with on-the-job and off-the-job experiences.

c. Adjustment to different size descriptions for consumer products such as clothing, food packaging, containers, fasteners, etc.

d. Familiarization with standard metric sizes, specifications, and related descriptions for those who work as machinists, carpenters, plumbers, sheet metal workers, etc.

e. Confusion of having two separate measuring systems existing at the same time.

During the transition period, personnel will not be able to instinctively think in terms of the SI system of measurement. This ability to think in the metric system will have to be developed from the start of the program. Converting personnel to thinking and visualizing in terms of metric units will result in a temporary loss of efficiency. An adequate training program will have to be established to minimize this loss of efficiency, and supervisory personnel will have to be encouraged to promote an understanding of the metric system. Every effort will have to be made to minimize these inconveniences, but no means exist for completely eliminating them. Stated simply, personnel will have to adjust to the metric system, putting aside personal opinions or resistance and living with the inconvenience, frustration, and difficulty of implementing the metric system.

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16. Should an emergency arise during the transition period, any metrication plan may have to be modified or reevaluated. If the emergency occurred in the early stages of conversion, a temporary suspension of conversion probably would be necessary. However, if hostilities should occur after the conversion is well advanced, it probably would be more efficient to accelerate the conversion process.

17. A most serious problem will be the development of an effective decision-making system. Decisions on when and how to change over from the inch-pound to the SI system of measurement can greatly affect the accomplishment and cost of each project. Therefore, a metrication coordinating office to advise or decide when and how to convert will have to be established.

D. Current Usage of Metric System in the DOD. The metric system currently is used to some extent within the DOD to perform specific functions. However, in terms of the total DOD mission, it is not used extensively. See Appendix G for areas of current usage.

E. Ability to Transit to the Use of the Metric System.

1. The study indicates that the DOD could transit to the use of the metric system without a major decrease in mission capability provided sufficient additional resources are available for the task. However, metrication would be costly and would allow limited military advantages while imposing numerous disadvantages during the transition period. Following transition, the military advantages expected are the day-to-day use of an inherently simpler system and the commitment of the Services to a single system of weights and measures. Further, should the adoption in the U.S. of the SI system lead to a world-wide standard for weights and measures, the result would be greater compatibility between U.S. and foreign operations and equipments. The completion of metrication will leave few long-term disadvantages. These will occur in the maintenance and support of long-life items which remain in the inventory well after the programmed metrication cycle. (For a detailed list of advantages and disadvantages, see Appendix D.)

2. The DOD is dependent upon the National Industrial Base and the rate of conversion within the DOD will be dependent on how well conversion is carried out by industry. The interfacing of equipments/components designed in the inch-pound and metric systems will present a formidable task. The availability of metric components will have to be known during the design process. Trade-off studies will have to be required to determine the degree of mix which could be tolerated in the engineering, support, and operational areas. DOD agencies must not be placed in the position of forcing the country to convert to metric units by requiring Government contracts to be written with metric requirements before industry has sufficiently converted. If DOD is placed in the position of forcing conversion, the cost to DOD and/or the decrease in Defense capability would greatly exceed the estimates made within this report. However, with proper planning, adequate funding and special attention to critical areas, it is envisioned that a successful conversion could be achieved.

V. CONCLUSIONS

A. Metrication within the DOD appears feasible provided sufficient and timely resources are made available and a national conversion schedule is adhered to by industry and DOD. It is imperative that close coordination be maintained between DOD and industry. Lack of such coordination will extend the conversion process and greatly increase the costs of conversion.

B. The total DOD cost for converting to the metric system while maintaining a constant mission capability is estimated to be approximately $18 billion with the rate of expenditure dependent upon the National Metrication Program. These costs are such that in the current environment, they cannot be absorbed without deterioration of the defense posture.

C. There are no major short-term advantages to the DOD in converting to the metric system.

D. The major problems in converting to the metric system will occur during the period of transition. These include psychological resistance to change, extensive training and retraining of personnel, operational and tactical conversion, logistics, equipment and system acquisition and conversion, and the development of metric standards.

E. The conversion of the country to the metric system could adversely impact on the ability of the United States to support its military forces during the proposed transition period. Without proper planning and adequate funding, the reduced flexibility and capacity of the support available would impact upon the capability of the Armed Forces to perform their mission, especially if an international crisis should develop at critical times during this period requiring the employment of major forces in a combat role.

F. The major advantages expected are the day-to-day use of an inherently simpler system and the compatibility of U.S. and foreign equipment. Although the use of a simpler system would have no outstanding advantage, the slight advantage expected would be significant because of its widespread nature. The compatibility of U.S. and foreign equipment will enhance combined operations and simplify the logistics support requirements.

G. The completion of metrication will leave few long-term disadvantages. Those that will occur deal with long-life items which will remain in inventory well after the programmed metrication cycle.

H. Inch-pound standards that have wide international acceptance should be retained until suitable metric standards are developed and accepted. In addition, the U.S. Government must actively participate with international organizations in the development of metric standards.

I. The interfacing of equipments/components designed in the inch-pound and metric systems will be a major task. The availability of metric components will have to be known during the design process. Trade-off studies will be required to determine the degree of mix which can be tolerated in the engineering, support, and operational areas. Metrication of new equipment designs can proceed on an orderly basis only if a phased national schedule for the conversion of major segments of U.S. industry is adopted.

J. A full-time and continuing staff within DOD will be required to prepare a detailed implementation plan for metrication. This same organization could administer and implement the metric system plan where appropriate.

VI. RECOMMENDATIONS

If a national decision is made to adopt the SI system, it is recommended that:

A. Aggressive action be taken to obtain in a timely manner those additional resources, in dollars and manpower, as are identified by affected DOD agencies.

B. A national schedule for metrication be developed before the requirement for metrication is placed on the U.S. Department of Defense.

C. A concerted effort be made by the Federal Government to foster and preserve the international use of U.S. customary standards that have wide international acceptance.

D. A staff be established within DOD to monitor and coordinate implementation of the metric system plan.

APPENDIX A

Historical Documentation

ASST SEC AIR FORCE (INSTALLATIONS & LOGISTICS) MEMO OF 16 October 1969

5 Attachments

1. Public Law 90-472
2. Deputy Secretary of Defense Memorandum, September 27, 1968
3. Guidelines
4. Assistant Secretary of the Air Force Memorandum, January 3, 1969
5. Secretary of the Air Force/Research & Development Memorandum, August 2, 1968

DEPARTMENT OF THE AIR FORCE
WASHINGTON 20330

OFFICE OF THE ASSISTANT SECRETARY

OCT 16 1969

MEMORANDUM FOR DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
CHAIRMAN, JOINT CHIEFS OF STAFF
DIRECTOR, DEFENSE COMMUNICATIONS AGENCY
DIRECTOR, DEFENSE ATOMIC SUPPORT AGENCY
DIRECTOR, DEFENSE SUPPLY AGENCY
DIRECTOR, DEFENSE INTELLIGENCE AGENCY
DIRECTOR, NATIONAL SECURITY AGENCY
SECRETARY OF THE ARMY
SECRETARY OF THE NAVY

SUBJECT: Metric System Study Under PL 90-472

On August 9, 1968, the President signed PL 90-472, a bill authorizing the Secretary of Commerce to conduct a study to determine the advantages, disadvantages and impact of increased worldwide use of the metric system on the United States (Atch 1). On September 27, 1968, the Deputy Secretary of Defense directed DOD participation in the study, and assigned leadership to the Air Force (Atch 2).

With the cooperation and participation of your representatives, guidelines for the conduct of this study have now been developed (Atchs 3 & 4). These are intended to provide a consistent basis for the estimation of impact on each DOD agency.

Within the framework of these guidelines, it is requested that each addressee analyze its own activities to measure, in accordance with PL 90-472, the advantages, disadvantages and impact of increasing worldwide use of the metric system and to report results to the DOD by September 1, 1970.

Since additional funds have not been appropriated for this purpose, your analysis must be carried out within existing resources. It is recommended, therefore, that a

minimal effort be expended consistent with the development of a competent position making use of sampling techniques wherever possible. Response in strict accordance with the requirements of the cost format (paragraph 7) and narrative questions (paragraph 9) of the guidelines paper will not be required. Further, as indicated in paragraph 2c of that paper, the problem of screw threads, fasteners, and similar devices should be eliminated from the study. The following questions should, however, be answered in some form:

a. With the 10-year cycle of metrication and assumptions described in the guidelines, what percentage increase in resources will be necessary to maintain constant mission capability?

b. What will be the long-term advantages and disadvantages after the 10-year metrication cycle is over?

c. To what extent are you already using the metric system of weights and measures?

d. What practical difficulties may be expected and what specific means do you recommend for meeting these?

e. Prepare and report a contingency plan for metrication.

f. Narrative comments by Commanders are invited regarding the effect of metric transition upon command mission capability.

Based on DOD policy, a position should not be taken either for or against adoption of the metric system.

Your continued cooperation in this effort is appreciated.

PHILIP N. WHITTAKER
Assistant Secretary of the Air Force
(Installations & Logistics)

5 Atchs
1. PL 90-472
2. DepSecDef memo,Sep 27, 68
3. Guidelines
4. Asst SecAF memo,Jan 3, 69
5. SAFRD memo, Aug 2, 68

Public Law 90-472
90th Congress, H. R. 3136
August 9, 1968

An Act

To authorize the Secretary of Commerce to make a study to determine the advantages and disadvantages of increased use of the metric system in the United States.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of Commerce is hereby authorized to conduct a program of investigation, research, and survey to determine the impact of increasing worldwide use of the metric system on the United States; to appraise the desirability and practicability of increasing the use of metric weights and measures in the United States; to study the feasibility of retaining and promoting by international use of dimensional and other engineering standards based on the customary measurement units of the United States; and to evaluate the costs and benefits of alternative courses of action which may be feasible for the United States. Metric system. Study.

SEC. 2. In carrying out the program described in the first section of this Act, the Secretary, among other things, shall— Investigation and appraisal requirements.

(1) investigate and appraise the advantages and disadvantages to the United States in international trade and commerce, and in military and other areas of international relations, of the increased use of an internationally standardized system of weights and measures;

(2) appraise economic and military advantages and disadvantages of the increased use of the metric system in the United States or of the increased use of such system in specific fields and the impact of such increased use upon those affected;

(3) conduct extensive comparative studies of the systems of weights and measures used in educational, engineering, manufacturing, commercial, public, and scientific areas, and the relative advantages and disadvantages, and degree of standardization of each in its respective field;

(4) investigate and appraise the possible practical difficulties which might be encountered in accomplishing the increased use of the metric system of weights and measures generally or in specific fields or areas in the United States;

(5) permit appropriate participation by representatives of United States industry, science, engineering, and labor, and their associations, in the planning and conduct of the program authorized by the first section of this Act, and in the evaluation of the information secured under such program; and

(6) consult and cooperate with other government agencies, Federal, State, and local, and, to the extent practicable, with foreign governments and international organizations.

SEC. 3. In conducting the studies and developing the recommendations required in this Act, the Secretary shall give full consideration to the advantages, disadvantages, and problems associated with possible changes in either the system of measurement units or the related dimensional and engineering standards currently used in the United States, and specifically shall— Results of changes in measurement system.

(1) investigate the extent to which substantial changes in the size, shape, and design of important industrial products would be necessary to realize the benefits which might result from general use of metric units of measurement in the United States;

(2) investigate the extent to which uniform and accepted engineering standards based on the metric system of measurement units are in use in each of the fields under study and compare the

extent to such use and the utility and degree of sophistication of such metric standards with those in use in the United States; and

(3) recommend specific means of meeting the practical difficulties and costs in those areas of the economy where any recommended change in the system of measurement units and related dimensional and engineering standards would raise significant practical difficulties or entail significant costs of conversion.

Report to Congress.

SEC. 4. The Secretary shall submit to the Congress such interim reports as he deems desirable, and within three years after the date of the enactment of this Act, a full and complete report of the findings made under the program authorized by this Act, together with such recommendations as he considers to be appropriate and in the best interests of the United States.

Funds.

SEC. 5. From funds previously appropriated to the Department of Commerce, the Secretary is authorized to utilize such appropriated sums as are necessary, but not to exceed $500,000, to carry out the purposes of this Act for the first year of the program.

Expiration date.

SEC. 6. This Act shall expire thirty days after the submission of the final report pursuant to section 3.

Approved August 9, 1968.

LEGISLATIVE HISTORY:

HOUSE REPORT No. 33 (Comm. on Science & Astronautics).
SENATE REPORT No. 1442 (Comm. on Commerce).
CONGRESSIONAL RECORD, Vol. 114 (1968):
June 24: Considered and passed House.
July 30: Considered and passed Senate.

GPO 98-139

THE DEPUTY SECRETARY OF DEFENSE

Washington, D.C. 20301

MEMORANDUM FOR The Secretaries of the Military Departments

SUBJECT: Public Law 90-472, 90th Congress, August 9, 1968

Reference: Memo for the Deputy Chief of Staff, R&D, USAF, dtd 28 Mar 1968, from DASD (Logistics Mgt. Systems & Programs), Subject: "Interagency Committee on Standards Policy"

In response to the reference, the Air Force accepted responsibility for representing the Department of Defense on the Metric Subcommittee of the Interagency Committee on Standards Policy, Department of Commerce. The Air Force has made significant and constructive contributions to the initial work of this Subcommittee.

The subject bill was approved by the President on August 9, 1968, and authorizes the Department of Commerce to conduct a program of investigation, research, and survey over a three year period to determine the impact of increasing world-wide use of the metric system on the United States. The bill clearly contemplates significant participation by the Department of Defense in identifying and defining the military interests in the conduct and results of this study. The effect on military operational and logistics support capability will necessarily constitute an important consideration in the conduct and evaluation of the study.

It is essential, therefore, that an objective, factual appraisal of the advantages and disadvantages to DoD of the metric system of measurement, and engineering standards expressed in metric terms, be developed as input for this national survey.

It is requested that the Air Force assume responsibility for leadership in developing plans for developing the above military input and leading the participation of the Department of Defense in the study authorized in the subject bill.

The Departments of the Army and Navy are requested to designate representatives qualified to assist the Air Force in the development of plans for the Department of Defense participation in this study. Please forward the names of your representatives to the Secretary of the Air Force within thirty (30) days of this memorandum.

The Air Force will, of course, wish to solicit input and participation from all Department of Defense components as the formulation of the plan for participation takes shape.

It is requested that a report of the initial formulation of plans for participation in the study, including resource requirements for supporting DoD participation, if any, be forwarded to the Assistant Secretary of Defense (Installations and Logistics) with a copy to the Director of Defense Research and Engineering, by January 1, 1969.

Paul H. Nitze

22 Aug 69

METRIC SYSTEM STUDY UNDER PL 90-472
Guidelines

1. TASK:

The task is to respond to PL 90-472. The principal part of this task is to conduct a program of investigation, research and survey to determine and report the impact of increased use of metric weights and measures on the capability of the military departments and DOD agencies to perform assigned missions during and after transition to a Metric System. The report will concern itself with 3 major efforts:

a. Appraise the desirability and practicability of increasing the use of metric weights and measures.

b. Determine the feasibility of retaining and promoting by international use of dimensional and other engineering standards based on the customary U.S. units of measurements.

c. Evaluate the costs and benefits of alternative courses of action which may be feasible.

To determine the impact on individual Military Departments and DOD agencies, these guidelines contain assumptions to aid the activities participating in the study by narrowing down the choices open to each activity so that uniform information will be developed that can readily be collated and incorporated in the National report. All of the activities must assume hypothetically that all military operational planning, training, weaponry, materiel, and logistic support will ultimately be accomplished utilizing only SI units of measure plus standard parts and materials that are acceptable on a national and where appropriate on an international basis. Under no circumstances will it be assumed, when making the study, that any military department or DOD agency has the authority, or the obligation to put the plan into effect either now or in the future, but rather that the study is to furnish information that is required under PL 90-472. The DOD report will be made to the Secretary of Commerce, who will report to the Congress.

2. ASSUMPTIONS:

In order to provide a firm basis for accurate results from a study of the impact of metrication upon the DOD the following is assumed:

a. Congress will have acted to adopt the Systeme International d'Unites (SI) system of weights and measures on 1 July 1972.

b. Assumed national metrication schedule

(1) 1 July 1972 - Preparation begins; metric training begins; specification up-dating in SI units initiated; use of SI units for new system development projects begins. General use of SI units optional.

(2) 1 July 1977 - Conversion begins; metric training accelerated; conversion of specifications for common items near completion; system development and design in SI units; metric procurement increasing; supply of metric items to operational organizations begins. General use of SI units increasing but not mandatory.

(3) 1 July 1982 - SI units compulsory; mandatory DOD use in engineering and procurement of new systems; replacement items still procurable in inch-pound units; non-SI items may be used to economic replacement point; new non-SI items introduced only by exception.

c. Based on an orderly program of metrication, industry will be capable of supporting DOD requirements in SI or inch-pound equipment until existing inch/pound equipment has completed its useful life.

d. It is assumed that during conversion the DOD will use the optimum mix of metric and inch-pound specifications for satisfactory performance and minimum price on initial buy of a new product. As of 1972 the optimum specifications may be inch-pound; as of 1982 these must be metric.

e. Existing force structure with numbers and types of weapon systems as of FY 70 Budget, will be assumed constant for the study with metric weapons systems and equipment replacing inch/pound as these end their useful lives.

3. GUIDANCE:

a. For the study, the "Metric System" is defined as the Système International d'Unités, abbreviated SI, as described by U.S. Department of Commerce Bureau of Standards Handbook 102, issued March 10, 1967. NOTE: This Handbook has been superseded by ASTM Standard Metric Practice Guide (see p. v for availability).

b. The President's Budget for FY 1970 will be used as a standard base for statements of fiscal impact.

c. Metrication will not disturb the normal cycle of retirement or modification of military system/equipment and related software.

d. The DOD report will be unclassified; but appendices (service/agency reports) may be classified according to content.

e. The reports of the military departments and DOD agencies will indicate cost and percentage change in mission capability due to metrication.

f. Conclusions must be supported by figures and documentation. Statements of long term advantages and disadvantages of metrication will be included.

g. Severe problem areas will be reported.

h. The Department of Commerce will report industry-wide increased cost due to metrication. The increased cost of commercially available off-the-shelf items will be included in the Department of Commerce report of industry-wide impact. The DOD study will be limited to the additional metrication costs to DOD over and above the industry-wide impact. To have a realistic report that DOD can support, the services/agencies must interface with industry, labor, science, education and other sectors of U.S. economy.

i. Observation of British, Canadian and other metric studies is encouraged.

j. Reporting agencies should recommend optimum metrication schedules in the event the assumed schedule is not considered feasible.

k. Reporting agencies should evaluate the costs and benefits of recommended alternative courses of action which may be feasible for the United States.

4. COST PRINCIPLES:

a. It is recognized that before cost estimates can be made a plan for metrication must be developed within the service or DOD agency to serve as a basis for measuring the metric impact. All impact cost estimates will be reported in terms of the military appropriation structure contained in the President's FY 70 Budget. The following major appropriations and funds will be considered:

(1) Operation and Maintenance

(2) Procurement and Production

(3) Research, Development, Test and Evaluation

(4) Military Construction

(5) Working Capital Funds

(6) Other (identify), e. g. Military Personnel, Family Housing, National Guard, etc.

Each service and DOD agency will develop cost estimates for each of the direct budget programs within the above listed appropriations and funds applicable to the reporting service or agency. Each service or DOD agency will use the appropriation/budget program definition pertinent to its area of operation.

b. Impact cost estimates will be made for each of four increments. The first and second will be five-year increments, 1972 to 1977 and 1977 to 1982. The third will be the ten-year period, 1982 to 1992; and the fourth, the remaining years that may be required subsequent to 1992 to complete the total change to the SI. Whenever cost estimates can be made on a FY basis these will be included as such and annotated as costs incurred in a specified FY.

c. All costs will be measured in FY 1970 dollars without an inflation factor. The intent is to represent in the final DOD report the average fiscal impact over the years in percentages based on Fiscal 1970 as an index of 100.

5. COST CRITERIA:

a. Wherever the changeover to the SI has an impact within the Department of Defense, the cost of metrication should be estimated for each period of the transition. Care must be exercised in arriving at a cost that measures metric impact only.

b. The metrication cost for producing and supporting a future weapon system in SI units would be the change in cost of the same weapon system produced and supported in customary units. Before the metric impact on storage requirements can be estimated, it must be determined which spares and supporting equipment could already have been available from existing stocks had the new weapon system been produced conventionally. Only those support items will be considered which generate a storage requirement solely because of metrication. Items peculiar to the new SI generate the same storage requirements as support items of previous non- SI.

c. If a publication is prepared solely for the purpose of educating and training personnel in the SI, the entire cost of the publication is chargeable. If, however, a technical publication on a current item of military hardware is written to include both SI and conventional units, then only the additional cost associated with metrication is chargeable.

d. Since the report to the Congress will include an estimate of the fiscal impact of a metric changeover on DOD, it is necessary that all metrication cost estimates be prepared in a manner which can be summarized into the appropriation structure of the President's Budget. All costs of metrication must be directly identified with a major budget activity or be described in detail so that such identity can be established. Additional man-hours and additional facilities required for metric changeover will be separately identified and priced in the cost estimates.

e. If an estimate of metric impact is made as a percentage of the total cost of a package of numerous budget sub-items, it will be necessary to convert the percent distribution of the total to dollars and assign these dollars to budget categories.

6. EXAMPLE FOR EXPRESSING COST IMPACT:

a. Impact cost estimates of metrication will be identified for each direct program within military appropriations. In measuring the impact cost estimates, the President's Budget for FY 1970 will be used as the base or index. This means that if it is estimated that trainer aircraft procurement cost was to increase by 2 million (M) dollars in one FY 76, due solely to metrication, the impact of the cost increase for that year would be expressed as $2M ÷ $55.3M (FY 1970 trainer aircraft procurement) or about 3.6%. This procedure will provide a measure for relating metrication cost increases in the individual appropriation accounts between periods.

b. The percentage impact on a major appropriation is derived by adding all the metrication costs within the appropriation and dividing the sum by the amount budgeted for this appropriation in FY 1970. If the FY 1970 budget shows $4,538.4M for the procurement of aircraft and a five year period metrication transition cost for this appropriation is completely accounted for by the $10M for trainers, plus $20M for airlift aircraft, $80M for combat aircraft and $220M for spares and support equipment, then the average yearly metrication percentage impact is 1.5% ($66M divided by $4,538.4M) for the five year aircraft procurement appropriation. The impact on the total appropriation for the transition period is similarly determined.

c. The dollar amounts used for metrication costs in the example above are purely ficticious and should not be interpreted as representative of what is expected. Metrication cost impact may be very small. Estimated cost impacts summing to less than .0001 (.01%) of a budget category may be disregarded.

7. REPORTING REQUIREMENTS

a. Each military department and defense agency will submit a cost impact report for each of the appropriation classifications listed in the President's budget. Within each appropriation cost estimates will be submitted for each of the major direct program categories constituting the agency appropriation. While these must be total estimates, it will be acceptable to derive the estimates by a sampling technique under which each agency will submit a sample program package that will be used as a basis for determination of a general metrication cost increment. The package must contain weapon systems, equipment, or other programs that will be truly representative of planned future defensive or offensive operations, and suitable for use in projecting metrication estimates for future weapon systems. It is desired to keep the size of the sample program package within reasonable limits, while providing an accurate and trustworthy base for metrication cost estimates.

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b. Cost data for each of the budget program categories will consist of all costs that are readily identifiable to each cost category regardless of how such costs might be financed. In addition to the total cost reported for each appropriation classification, the following data generated by metrication will be reported:

(1) Additional man-years and equivalent manpower cost

(2) Additional facilities cost

(3) Additional equipment cost

(4) Total costs

c. Technical data is of specific interest for this study. It will be included in the total cost estimates and will be identified, itemized, and costed separately. Impact statements will be required regarding the capability to prepare, acquire, update, process, use and disseminate technical data required for research, development, test and evaluation, quality assurance, procurement, production, reprocurement, maintenance and operation of military equipment/ systems.

d. Reports will be prepared in triplicate. Illustrative formats are attached.

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

(ILLUSTRATIVE FORMAT)

APPROPRIATION: OPERATION AND MAINTENANCE

DEPARTMENT OR AGENCY:

O&M (DIRECT PROGRAMS)	Estimated Cost Impact							
	1972 - 1977		1977 - 1982		1982 - 1992		1992 - ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Operating Forces								
Training								
Supply								
Maintenance								
Medical Services								
Servicewide Support								
Reserve Forces								
Other Direct Programs								
Total O&M Costs								
Manyears								
Dollars								
Fclty & Equip - Dollars								

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

(ILLUSTRATIVE FORMAT)

APPROPRIATION: RESEARCH, DEVELOPMENT, TEST & EVALUATION

DEPARTMENT OR AGENCY:

RDT&E (DIRECT PROGRAMS)	Estimated Cost Impact							
	1972 - 1977		1977 - 1982		1982 - 1992		1992 - ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Military Sciences								
Acft & Related Equip								
Mil Astro & Related Equip								
Ship, Small Craft & Related Equip								
Ord, Cmbt Vehs & Related Equip								
Other Equipment								
Fclty & Installation Spt								
Total RDT&E Costs								
Manyears								
Dollars								
Fclty & Equip - Dollars								

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

(ILLUSTRATIVE FORMAT)

APPROPRIATION: PROCUREMENT OF EQUIPMENT AND MISSILES

DEPARTMENT OR AGENCY:

PEMA (DIRECT PROGRAMS)	Estimated Cost Impact							
	1972 - 1977		1977 - 1982		1982 - 1992		1992 - ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Aircraft								
Acft Spares & Repair Parts								
Missiles								
Msl Repair Parts & Spt Mat								
Wpns, Tracked Cmbt Vehs & Nontracked Cmbt Veh								
Tac & Spt Vehs								
Comm & Elect Equip								
Other Spt Equip								
Ammunition								
Production Base Support								
Total PEM, A Costs								
Manyears								
Dollars								
Fclty & Equip - Dollars								

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

APPROPRIATION: OTHER

DEPARTMENT OR AGENCY:

MILITARY CONSTRUCTION (DIRECT PROGRAMS)	Estimated Cost Impact							
	1972 - 1977		1977 - 1982		1982 - 1992		1992 - ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Major Construction								
Minor Construction								
Planning								
Total Mil Const Costs								
Manpower-Manyears Dollars								
Fclty & Equip - Dollars								
Military Personnel								
Total Mil Personnel Costs								
Manpower - Manyear Dollars								
Stock Fund								
Total Stock Fund Costs								
Other Appropriations								
Total Costs								
Manyear Dollars								
Fclty & Equip - Dollars								

8. MILESTONES:

The milestone progress chart attached indicated progress reporting requirements, as follows:

a. Identify an office of primary responsibility.

b. Establish and submit a metrication plan in accordance with paragraph 4.a not later than 1 December 1969. (1st Progress Report)

c. By 1 January 1970 identify and submit slight impact areas for elimination from the study.

d. By 1 January 1970 identify and submit areas where metrication is impractical.

e. By 1 January 1970 identify and submit serious impact areas.

f. By 1 March 1970 assemble preliminary documentation. (2nd Progress Report)

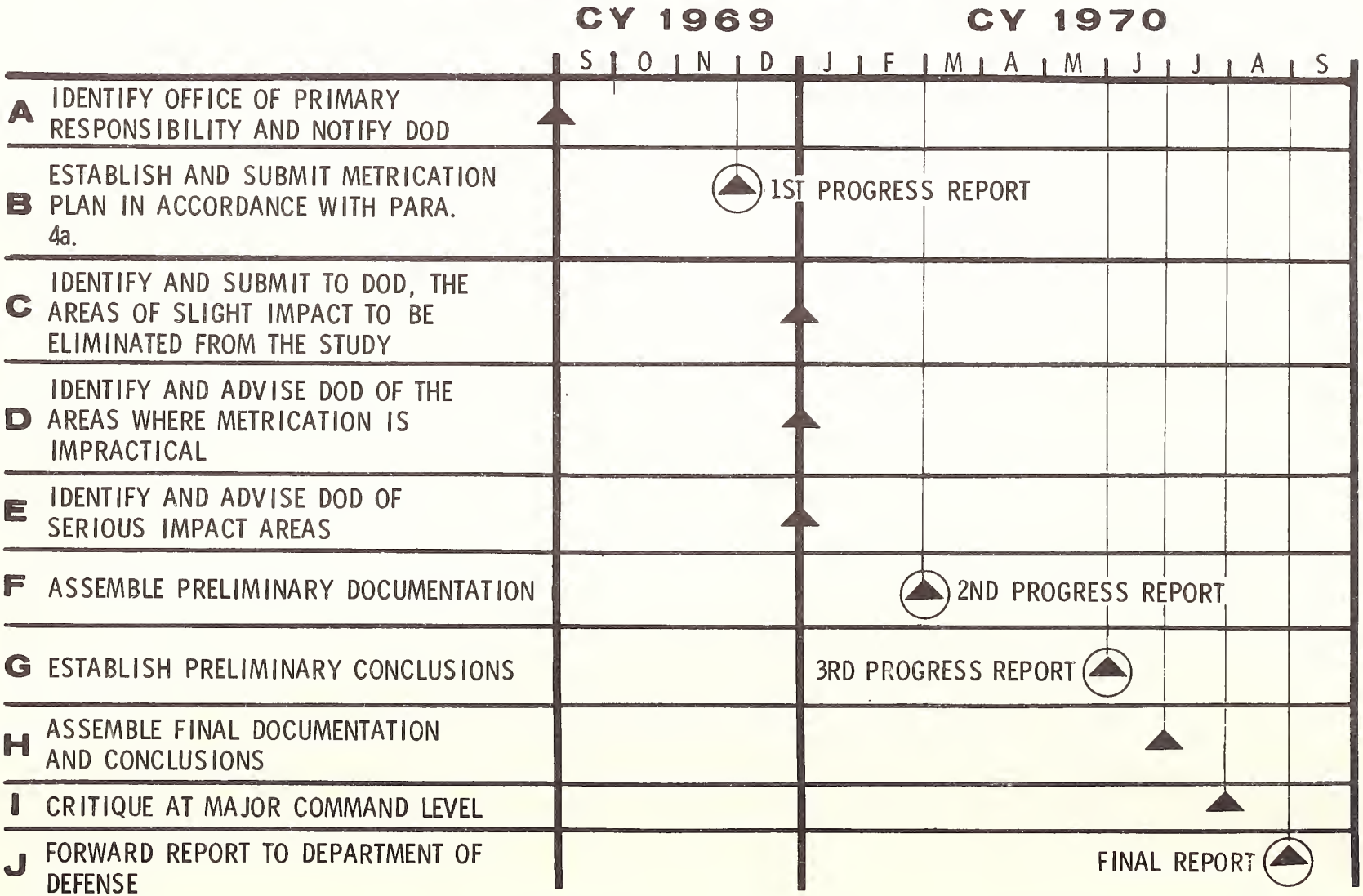
g. By 1 June 1970 establish preliminary conclusions. (3rd Progress Report)

h. By 1 July 1970 assemble final documentation and conclusions.

i. By 1 August 1970 critique at major command levels.

j. By 1 September 1970 report to DOD.

MILESTONES


CY 1969
CY 1970
S O N D J F M A M J J A S
A IDENTIFY OFFICE OF PRIMARY RESPONSIBILITY AND NOTIFY DOD
B ESTABLISH AND SUBMIT METRICATION PLAN IN ACCORDANCE WITH PARA. 4a.
1ST PROGRESS REPORT
C IDENTIFY AND SUBMIT TO DOD, THE AREAS OF SLIGHT IMPACT TO BE ELIMINATED FROM THE STUDY
D IDENTIFY AND ADVISE DOD OF THE AREAS WHERE METRICATION IS IMPRACTICAL
E IDENTIFY AND ADVISE DOD OF SERIOUS IMPACT AREAS
F ASSEMBLE PRELIMINARY DOCUMENTATION
2ND PROGRESS REPORT
G ESTABLISH PRELIMINARY CONCLUSIONS
3RD PROGRESS REPORT
H ASSEMBLE FINAL DOCUMENTATION AND CONCLUSIONS
I CRITIQUE AT MAJOR COMMAND LEVEL
J FORWARD REPORT TO DEPARTMENT OF DEFENSE
FINAL REPORT

9. NARRATIVE RESPONSES:

In addition to the cost estimates required by paragraphs 4, 5, 6 and 7, additional data are required to amplify and provide further clarification to assist in the identification of the advantages/ disadvantages of increased use of the SI in the DOD.

The following questions reflect areas of hard core interest that must be addressed. In some instances there will be RDT&E questions that apply equally as well to other functional areas such as production, technical data, etc. It is recognized that additional questions may arise during the course of the study. These questions also should be identified and included in the overall analysis/ evaluation.

a. General:

(1) What are the military advantages or disadvantages in adopting an internationally standardized system of weights and measures?

(2) What will be the long term advantage or disadvantage of adopting the SI; or of retaining the customary system of units?

(3) To what extent are uniform and accepted engineering standards, based upon the SI units in use in United States military activities?

(4) Identify those dimensional and other engineering standards that should be replaced with international metric standards; those based on customary measurement units of the United States that should be retained and proposed for international adoption. Are there dimensional and other engineering standards that are a problem separate and apart from the conversion to SI weights and measures?

(5) What affect will metrication have on lead times? (Include RDT&E, Procurement, Production, Planning, Training, etc.)

(6) Are there any military advantages of metrication such as ease in working with allies that have the same standard system of weights and measures? Will this affect military capability? How?

b. Operations:

(1) Will metrication affect operational capability and readiness during periods of hostilities, deployments or other operational contingencies? If so, what will be the effect?

(2) How will metrication affect maintenance of equipment? Would this impact on an operational capability?

(3) Will the hours required for training reduce the manning of units and affect operational capability? If so, to what extent?

(4) Will there be any effect on operational capability due to personnel converting mentally from one system to another instead of reacting instinctively? If so, what would be the extent?

(5) What factors not covered above should be considered in assessing the impact of metrication on operational capabilities? (Identify these areas and discuss).

c. Research, Development, Test and Evaluation:

(1) What will be the impact on systems/equipment management dealing with the weapon performance during the development and acquisition of equipment produced from SI designs?

(2) What will be the impact of metricating scientific and technical areas? (i.e., labs, test facilities, etc.)

(3) Will metrication affect the performance of weapon systems and supporting equipment?

d. Production and Procurement:

(1) Considering that it will be necessary to establish a production capability in both SI and inch/pound systems, how will this affect total production capability? (include government-owned, contractor-operated and government-owned, government-operated plants).

(2) How will metrication affect industrial readiness planning during periods of hostilities or other military commitments?

(3) Would priorities be assigned to categories of technical data for the change to the SI? If so, how?

(4) During the period 1972 through 1977 and 1977 through 1982, what technical data would and would not be converted? State answer in percent of total.

e. Materiel Support (Supply, Maintenance and Transportation):

(1) How will metrication affect transportation, i.e., cargo containers, cube and weight computations, freight classifications, instructions, etc.?

(2) What problems will be encountered in maintenance facilities where equipment and tools will be required to support two systems, one inch and one SI?

f. Facilities, Installations and Military Construction:

(1) What would be the impact on planning and designing new construction in SI units?

(2) How would metrication affect real estate purchases?

(3) What will be the effect on maintenance of buildings, heating, air conditioning, plumbing, etc.?

g. Legal:

(1) What legal problems will confront the DOD as a result of metrication?

(2) What changes will be necessary to existing directives and regulations including ASPR, technical manuals, etc.?

(3) What savings or exception clauses must be included in ultimate law for metrication?

(4) What new or modified legislation will be required?

(5) What enforcement provisions will be necessary in the metrication law?

h. Personnel and training:

(1) Recognizing that different levels of training will be required due to job classifications, give estimate of amount of training and how this training would be accomplished, i.e., familiarization, OJT, informal, formal, Field Training Detachment, etc.

(2) Identify and list areas where extensive training would be required due to metrication?

(3) Identify areas where long range benefits would result from a change to the SI.

i. Commanders Estimate:

Considering the answers to all of the above, summarize the impact of the planned metrication on your ability to carry out your mission.

January 3, 1969

MEMORANDUM FOR DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
CHAIRMAN, JOINT CHIEFS OF STAFF
DIRECTOR, DEFENSE COMMUNICATIONS AGENCY
DIRECTOR, DEFENSE ATOMIC SUPPORT AGENCY
DIRECTOR, DEFENSE SUPPLY AGENCY
DIRECTOR, DEFENSE INTELLIGENCE AGENCY
DIRECTOR, NATIONAL SECURITY AGENCY
SECRETARY OF THE ARMY
SECRETARY OF THE NAVY

SUBJECT: PL 90-472 Metric System Study within Department of Defense

On August 9, 1968, the President signed PL 90-472, an act "to authorize the Secretary of Commerce to make a study to determine the advantages and disadvantages of increased use of the metric system in the United States." (Attachment #1)

On September 27, 1968, the Deputy Secretary of Defense assigned to the Air Force leadership in the participation of the Department of Defense in the study authorized by PL 90-472. (Attachment #2) A DOD steering committee has been established which is proposing tentative guidelines for the method and timeframe for conversion. (Attachment #3) Other Departments of the Government are also participating and will report to the Commerce Department.

It is desired that each agency addressed participate in the development of final guidelines for uniform conduct of the military Departments' participation in the PL 90-472 study. The final guidelines should be based on a reasonable approach which will produce uniform and compatible responses from the DOD agencies and at the same time provide answers to Congressional questions. A May 1, 1969, target date is established for completion of comment by addressees.

The period from July 1, 1969, to July 1, 1970, would then be used for the actual survey, determination of impact, and report to this office. Evaluation and collation of reports, rechecks, and report through Commerce Department to the Congress would be done before January 1, 1971.

It is emphasized that the task of the Department of Defense and its agencies is one of measuring in hard numbers the impact of the proposed adoption of the metric system; advocacy or opposition to the metric system is not a part of the task.

Recognizing that there will be a continuing need during the study for establishment of common reporting procedures and definitions, and for consideration and solution of common agency problems in the measurement of metric impact, nine ad hoc advisory committees are being established at the Department of Defense level. (Attachment #4) Questions on definitions and procedure, or of a nature common to several agencies, will be accepted by this office for referral to the steering committee. Certain of the addressees will be requested, by separate correspondence, to provide members for the ad hoc committees.

Change to metric units will be decided upon by the Congress after consideration of the Secretary of Commerce report and appropriate debate.

The study is to be accomplished within available resources.

4 Atch
1. PL 90-472
2. Sep 27 memo fr Dep SecDef
3. Tentative Guidelines
4. Ad Hoc Advisory Comm

(signed)
ROBERT H. CHARLES
Assistant Secretary of the Air Force
(Installations & Logistics)

Dear Mr. Director:

Reference is made to your request to the Secretary of Defense for the views of the Department of Defense with respect to the enrolled enactment of H. R. 3136, 90th Congress, an Act "To authorize the Secretary of Commerce to make a study to determine the advantages and disadvantages of increased use of the metric system in the United States." The Secretary of Defense has delegated to the Department of the Air Force the responsibility for expressing the views of the Department of Defense.

The purpose of H. R. 3136 is as stated in the title.

The Department of the Air Force, on behalf of the Department of Defense, recommends the approval and signature by the President of H. R. 3136.

Approval of H. R. 3136 will not result in an increase in the budgetary requirements of the Department of Defense.

This report has been coordinated within the Department of Defense in accordance with procedures prescribed by the Secretary of Defense.

Sincerely,

ALEXANDER H. FLAX
Assistant Secretary
Research and Development

Honorable Charles J. Zwick
Director
Bureau of the Budget

DEPARTMENT OF THE AIR FORCE
WASHINGTON 20330

JAN 7 1970

FFICE OF THE SECRETARY

MEMORANDUM FOR DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
CHAIRMAN, JOINT CHIEFS OF STAFF
DIRECTOR, DEFENSE COMMUNICATIONS AGENCY
DIRECTOR, DEFENSE ATOMIC SUPPORT AGENCY
DIRECTOR, DEFENSE SUPPLY AGENCY
DIRECTOR, DEFENSE INTELLIGENCE AGENCY
DIRECTOR, NATIONAL SECURITY AGENCY
SECRETARY OF THE ARMY
SECRETARY OF THE NAVY

SUBJECT: Metric System Study Under PL 90-472

By memorandum of October 16, 1969 the addressees were asked to comply with PL 90-472 by measuring the impact of metrication within each addressee's own activities.

The fourth paragraph of the October 16, 1969 memorandum excluded the "problem of screw threads, fasteners, and similar devices" from the DOD metrication study.

The Department of Commerce has taken exception to this exclusion since their overall report to Congress will include a consideration of the general problem of standards and specifications conversion, of which screw threads, fasteners and similar devices are an important part. Contributing surveys by industry and other Government agencies will be based on the assumption that all standard parts will be available in SI units during the assumed 10-year metrication period.

Accordingly, addressees are requested to include in the subject study the impact of conversion of all DOD standards and specifications for which the addressee's agency has prime responsibility. It will be assumed that industrial standards and specifications will be converted by industry

at a uniform rate between 1972 and 1982 and that Federal standards or specifications not under DOD cognizance will be converted by the responsible agency. Any standards or specifications used by DOD agencies and not covered by this memorandum should be reported to the Metric System Study Office or to this office.

PHILIP M. WHITTAKER
Assistant Secretary of the Air Force
Installations & Logistics

1 Atch
Commerce Dept ltr
Nov 26, 1969

APPENDIX B

Assumptions

In order to provide a firm basis for accurate results from a study of the impact of metrication upon the DOD, the following was assumed:

A. The "metric system" referred to in this report is defined to be the International System of Units (SI), also known as the Modern Metric System. Units associated with this system are as follows:

Measurement	Unit	Symbol
length	meter	m
mass	kilogram	kg
time	second	s
temperature	kelvin	K
electric current	ampere	A
luminous intensity	candela	cd

B. Congress will have acted to adopt the SI system of weights and measures by July 1972.

C. A national metrication schedule of 10 years. The program of metrication will effectively be completed at the end of this period.

1. July 1972 - Preparation begins; metric training begins; specification and standards updating in SI units initiated; use of SI units for new system development projects begins. General use of SI units optional.

2. July 1977 - Conversion begins; metric training accelerated; conversion of specifications for common items near completion; system development and design in SI units; metric procurement increasing; supply of metric items to operational organizations begins. General use of SI units increasing but not mandatory.

3. July 1982 - SI units compulsory; mandatory DOD use in engineering and procurement of new systems; replacement items still procurable in inch-pound units; non-SI items may be used to economic replacement point; new non-SI items introduced only by exception.

D. Based on an orderly program of metrication, industry will be capable of supporting DOD requirements in SI or inch-pound equipment until existing inch-pound equipment has completed its useful life.

E. Unless there are distinct advantages in changing, metrication will not disturb the normal cycle of retirement or modification of system/equipment.

F. It is assumed that during conversion the DOD will use the optimum mix of metric and inch-pound specifications for satisfactory performance and minimum price on initial buy of a new product. As of 1972 the optimum specifications may be inch-pound; as of 1982 they must be metric.

G. Existing force structure with numbers and types of weapons systems as of FY 70 Budget, will be assumed constant for the study with metric weapons systems and equipment replacing inch-pound as these end their useful lives.

APPENDIX C

Agency Cost Data

ARMY COST ESTIMATES

The projected cost of metrication of the Army is approximately $4.35 billion to be spent over a 30-year period. The highest costs are expected during the seventh through tenth years of the conversion. Tables 1 through 5 summarize the costs expected during the metrication process. These cost estimates are based on reports from 36 Headquarters organizations, extrapolated to represent the total Army budget. Most of these 36 reports were extensive compilations of subordinate activity and installation reports. Figures 1 through 10 illustrate the annual costs and cumulative costs for the total Army Budget and Major Appropriations.

TABLE 1

APPROPRIATION: Operation and Maintenance

ORGANIZATION: U. S. Army

DIRECT PROGRAM	FISCAL CODE	1970 BUDGET	COST INCREASES DUE TO METRICATION							
			1972 - 1977		1977 - 1982		1982 - 1992		1992 - ...	
			%	Dollars	%	Dollars	%	Dollars	%	Dollars
Operating Forces	2000.0000-2090-0000	2,974,803	1.14	33,789	1.93	57,482	1.29	38,447	.67	20,076
Training Activities	2100.0000-2190.0000	811,881	.86	6,993	.80	6,457	.34	2,751	.004	29
Central Supply Activities	2200.0000-2290.0000	1,719,126	1.94	33,310	5.28	90,800	1.38	23,696	1.03	17,681
Depot Materiel Maintenance & Support	2300.0000-23X0.19900	740,549	2.21	16,364	5.65	41,807	7.26	53,797	.82	6,059
Medical Services Activities	2400.0000-2490.0000	399,331	.06	228	.16	634	.01	48	-	-
Army Wide Activities	2500.0000-2590.0000	315,917	.32	1,007	.28	871	.15	461	.12	385
Reserve Forces	2600.0000-2690.0000	110,144	.19	212	.52	577	.56	612	.24	260
Intelligence Army Wide Communications & US Army Photographic Agency Activities	2800.0000-2890.0000 2900.0000-2990.0000	161,249 193,646	.47	754 417	1.04 .72	1,682 1,391	1.27 .31	2,052 594	.28 -	448 -
Base Operations	9000.0000-9090.0000	-	.22	-	-	-	-	-	-	-
TOTAL		7,426,646	1.25	93,074	2.72	201,701	1.65	122,458	.61	44,938

All costs are expressed as annual costs
All dollar values are expressed in thousands

TABLE 2

APPROPRIATION: Research, Development, Test & Evaluation ORGANIZATION: U. S. Army

DIRECT PROGRAM	FISCAL CODE	1970 BUDGET	COST INCREASES DUE TO METRICATION							
			1972 - 1977		1977 - 1982		1982 - 1992		1992 - ...	
			%	Dollars	%	Dollars	%	Dollars	%	Dollars
Military Sciences	5000.0000-505A.0000	162,683	.07	144	.09	146	.05	81	.04	65
Aircraft & Related Equipment	5100.0000-517B.0000	94,777	.7	663	1.0	948	.14	132	.09	85
Missiles & Related Equipment	5200.0000-527J.0000	853,430	1.06	9,046	1.0	8,534	.94	8,022	.94	8,022
Miltary Astronautics & Related Equipment	5300.0000-537A.0000	9,300	-	-	-	-	-	-	-	-
Ships, Small Craft & Related Equipment	5400.0000-544A.0000	400	-	-	-	-	-	-	-	-
Ordance, Combat Vehicles, & Related Equipment	5500.0000-557E.0000	153,412	.62	951	6.2	9,512	1.86	2,853	.05	77
Other Equipment	5600.0000-567K.0000	304,318	.84	2,556	1.4	4,260	1.24	3,773	.84	2,556
Program Wide Management & Support	5700.0000-5790.0000	51,500	1.82	937	1.8	927	2.03	1,045	1.11	571
TOTAL		1,629,820	.87	14,267	1.49	24,327	.97	15,906	.69	11,386

All costs are expressed as annual costs
All dollar values are expressed in thousands

TABLE 3

APPROPRIATION: Procurement of Equipment and Missiles ORGANIZATION: U.S. Army

DIRECT PROGRAM	FISCAL CODE	1970 BUDGET	COST INCREASES DUE TO METRICATION							
			1972 - 1977		1977 - 1982		1982 - 1992		1992 - ...	
			%	Dollars	%	Dollars	%	Dollars	%	Dollars
Aircraft	4000.0000-4098.0000	385,700	.18	694	.29	1,118	.20	771	.05	192
Aircraft Spares & Repair Parts	41000.0000	85,200	.19	161	.30	255	.22	187	.04	34
Missiles	4200.0000-4299.0000	774,100	.10	774	.12	928	.03	232	-	-
Missile Repair Parts & Support Materiel	4300.0000-4380.0000	44,500	-	-	-	-	-	-	-	-
Weapons, Tracked Combat Vehicles & Non-tracked Combat Vehicles	4400.0000-4498.0000	304,100	.02	60	2.93	8,910	1.92	5,838	-	-
Tactical & Support Vehicles	4500.0000-4530.0000	426,000	-	115	-	230	-	-	-	-
Communications & Electronic Equipment	4600.0000-4630.0000	315,000	.29	913	3.57	11,245	.48	1,512	.11	346
Other Support Equipment	4700.0000-4770.0000	284,700	.17	484	.17	484	.07	199	-	-
Ammunition	4800.0000-4820-0000	1,729,300	.61	10,548	.61	10,548	.30	5,188	-	-
Production Base Support	4900.0000-4933.0000	312,100	2.54	7,927	3.22	10,049	2.87	8,957	.01	31
TOTAL		4,660,700	.46	21,676	.93	43,767	.49	22,884	.01	603

All costs are expressed as annual costs.
All dollar values are expressed in thousands.

TABLE 4

APPROPRIATION: Military Construction, Army

ORGANIZATION: U. S. Army

DIRECT PROGRAM	FISCAL CODE	1970 BUDGET	COST INCREASES DUE TO METRICATION							
			1972 -1977		1977 - 1982		1982 - 1992		1992 - ···	
			%	Dollars	%	Dollars	%	Dollars	%	Dollars
Major Construction	6100.0000-6100.5500	307,928	.51	1,561	.51	1,561	.08	260	0	-
Minor Construction	6600.0000	10,000	.03	3	.16	16	.05	5	0	-
Planning	6300.0000-6300.30000	39,698	1.25	495	1.25	495	1.06	420	1.06	420
Other	6400.0000-6500.30000 6800.0000-6800.20000	60,800	0	-	0	-	0	-	0	-
TOTAL		418,426	.49	2,059	.49	2,072	.16	686	.10	420

All costs are expressed as annual costs.
All dollar values are expressed in thousands.

TABLE 5

MISCELLANEOUS APPROPRIATIONS: ORGANIZATION: U.S. Army

APPROPRIATION	FISCAL CODE	1970 BUDGET	COST INCREASES DUE TO METRICATION							
			1972 - 1977		1977 - 1982		1982 - 1992		1992 - ···	
			%	Dollars	%	Dollars	%	Dollars	%	Dollars
Military Personnel Army	1000.0000-1540.0000	8,670,000	.01	1,174	-	464	-	259	-	88
National Guard Personnel, Army	3100.0000-3158.0000	390,700	.01	53	-	21	-	12	-	4
Reserve Personnel, Army	3200.0000-3331.00	329,600	-	30	-	1	-	1	-	0
Operation & Maintenance, Army National Guard	3700.0000-3745.0000	312,600	1.25	3,907	2.72	8,503	1.65	5,158	.6	1,876
Military Construction Army National Guard	8500.0000-8551.0000	15,000	.06	9	.06	9	.03	5	-	1
Military Construction Army Reserve	8600.0000-8651.0000	10,000	.56	56	.56	56	.28	28	-	-
Others										
TOTAL MISCELLANEOUS		9,727,900		5,229		9,054		5,463		1,969
GRAND TOTAL, ARMY APPROPRIATIONS		23,863,492	.57	136,305	1.17	280,921	.70	167,397	.24	59,316

All costs are expressed as annual costs
All dollar values are expressed in thousands

ARMY BUDGET
METRICATION COST PROFILE

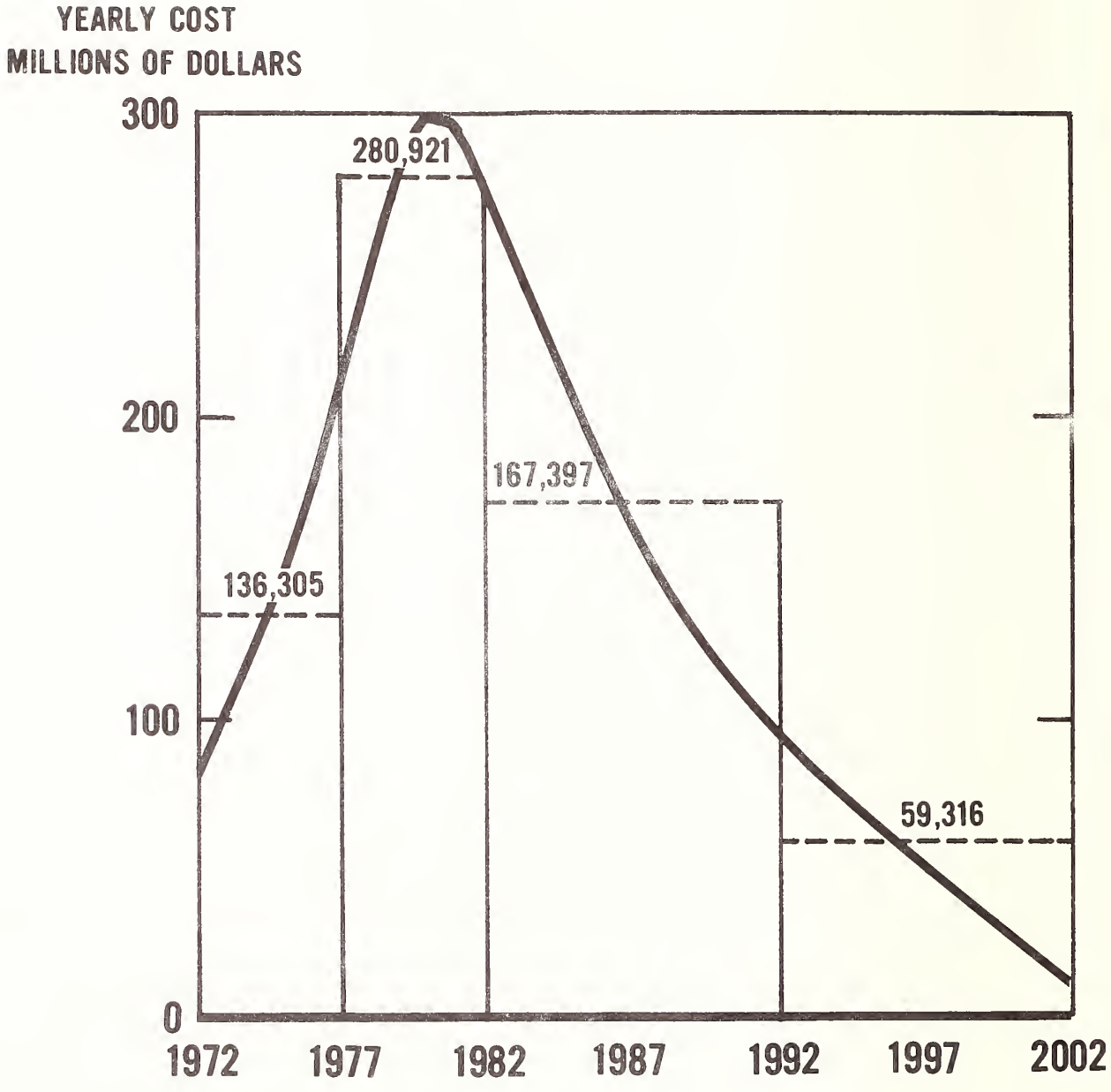


FIGURE 1

ARMY BUDGET,
CUMULATIVE COSTS OF METRICATION

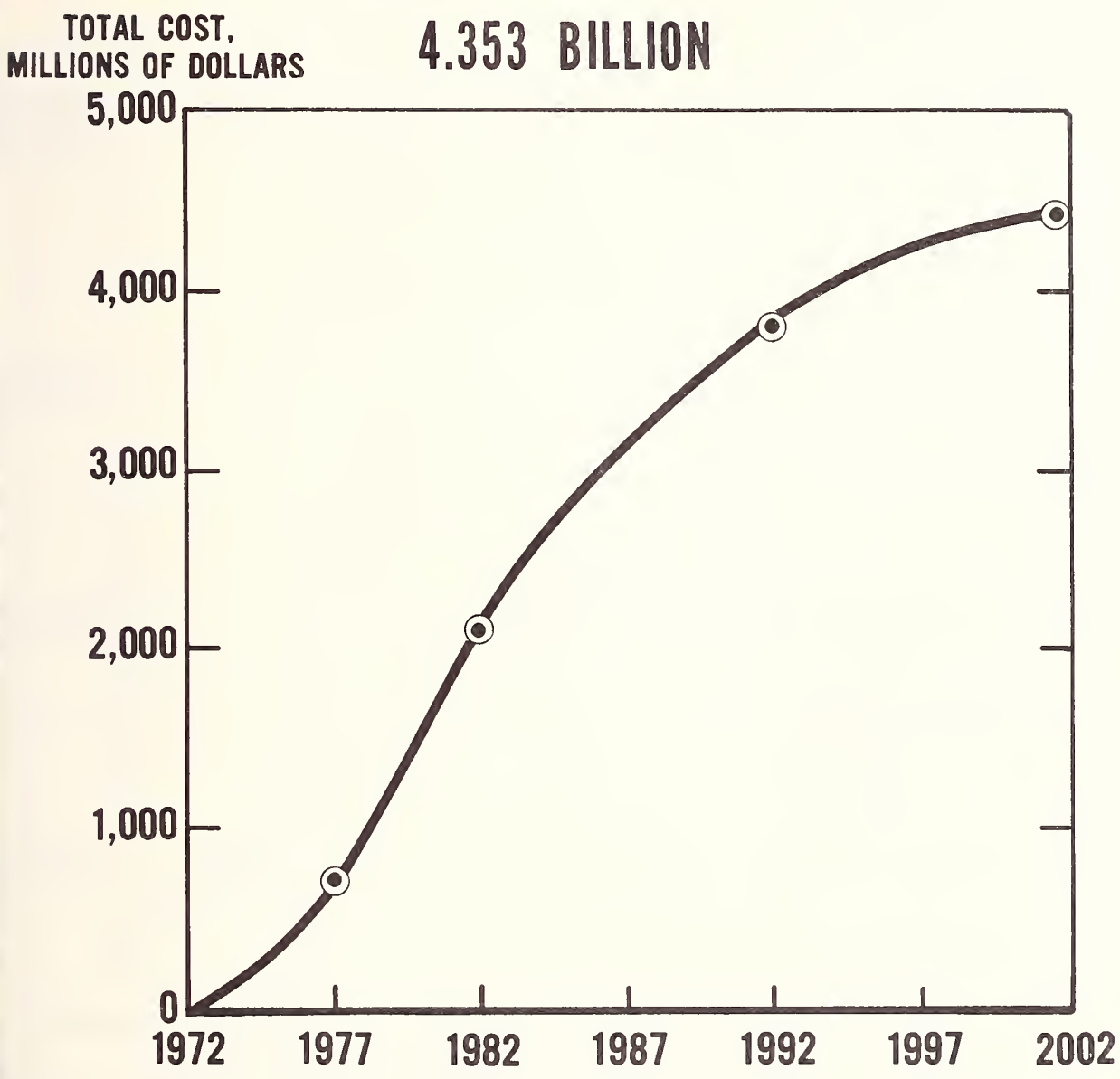


FIGURE 2

OPERATION AND MAINTENANCE METRICATION COST PROFILE

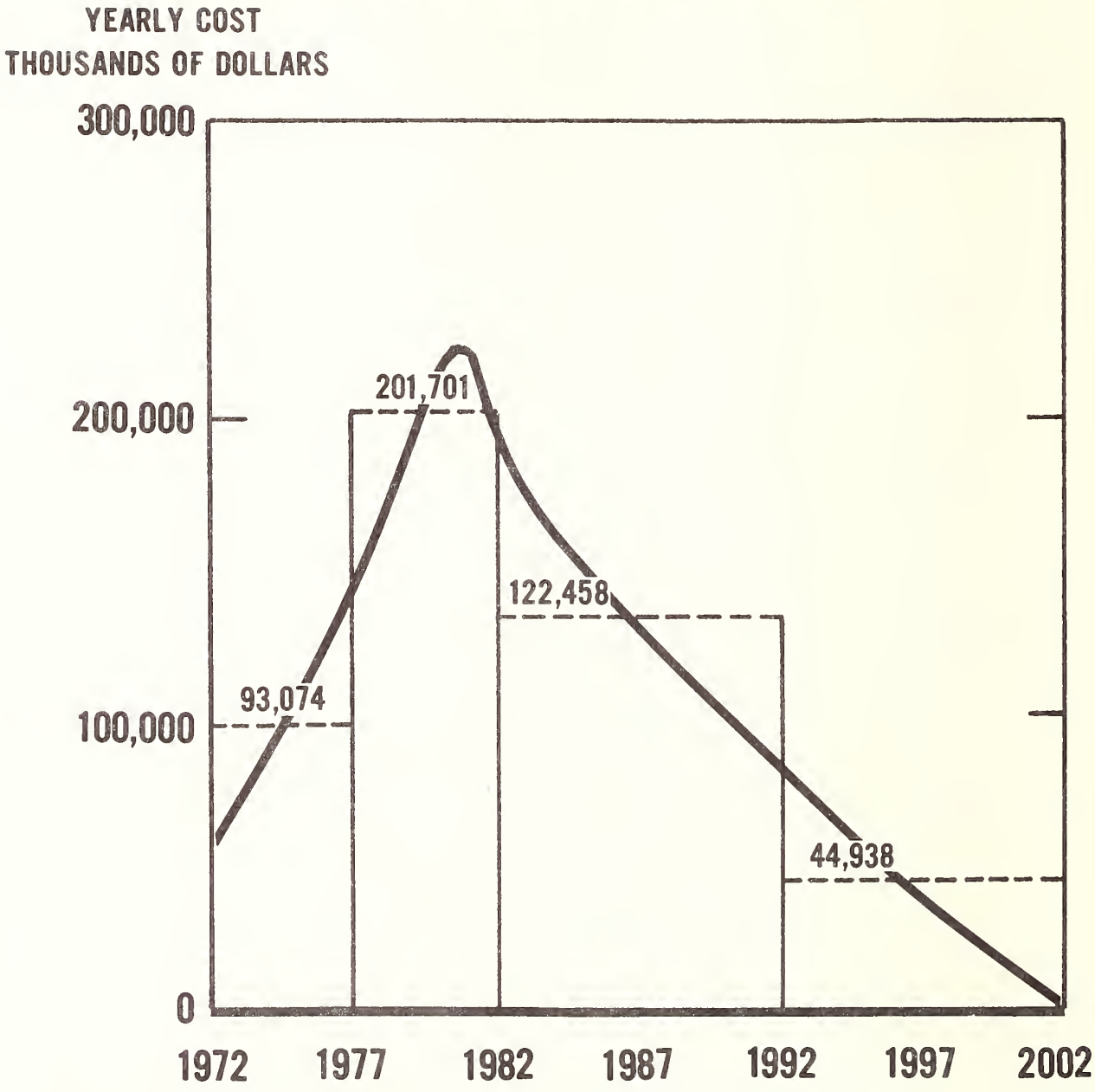


FIGURE 3

OPERATION & MAINTENANCE
CUMULATIVE COST OF METRICATION

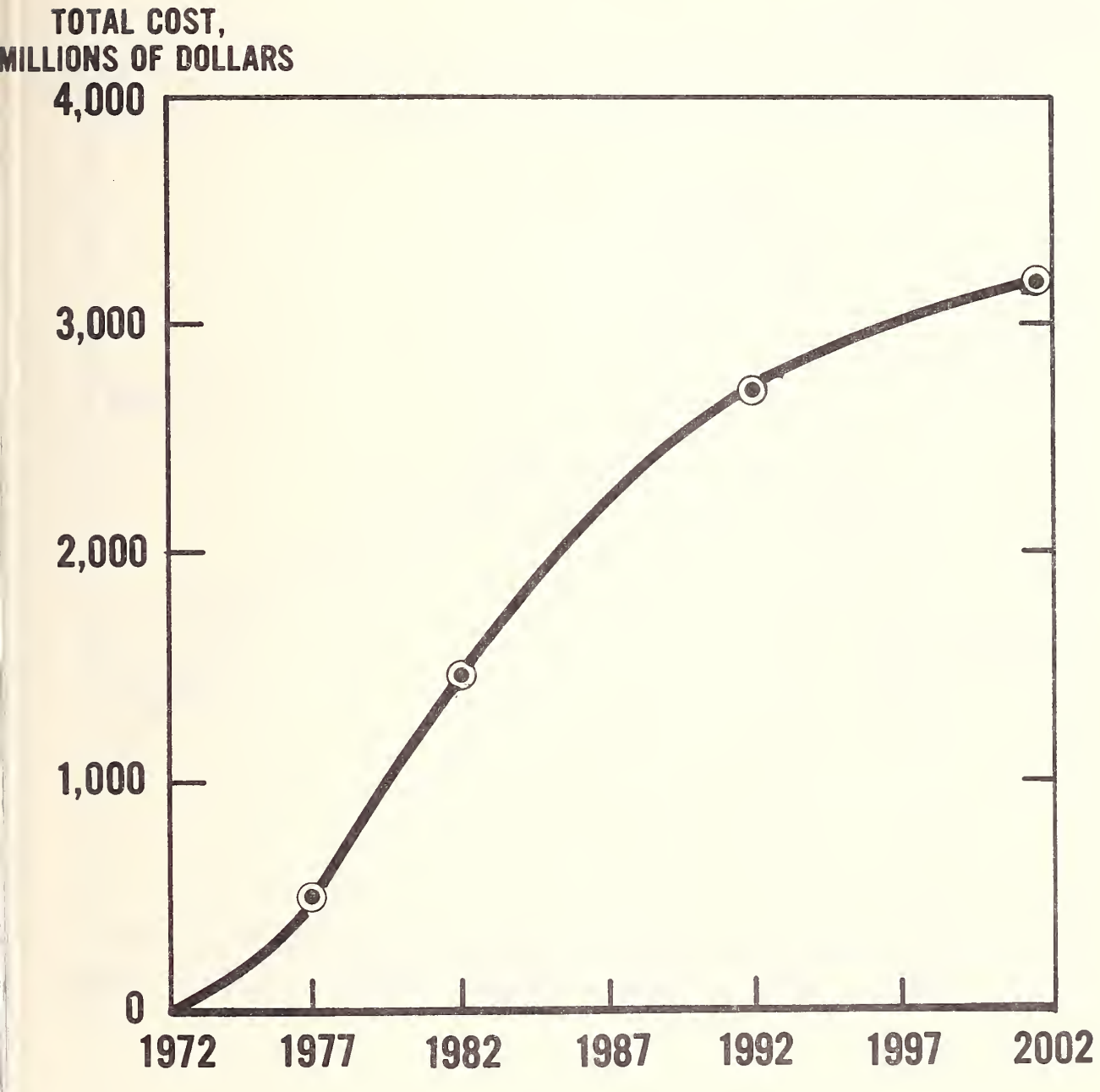


FIGURE 4

RESEARCH, DEVELOPMENT, TEST & EVALUATION METRICATION COST PROFILE

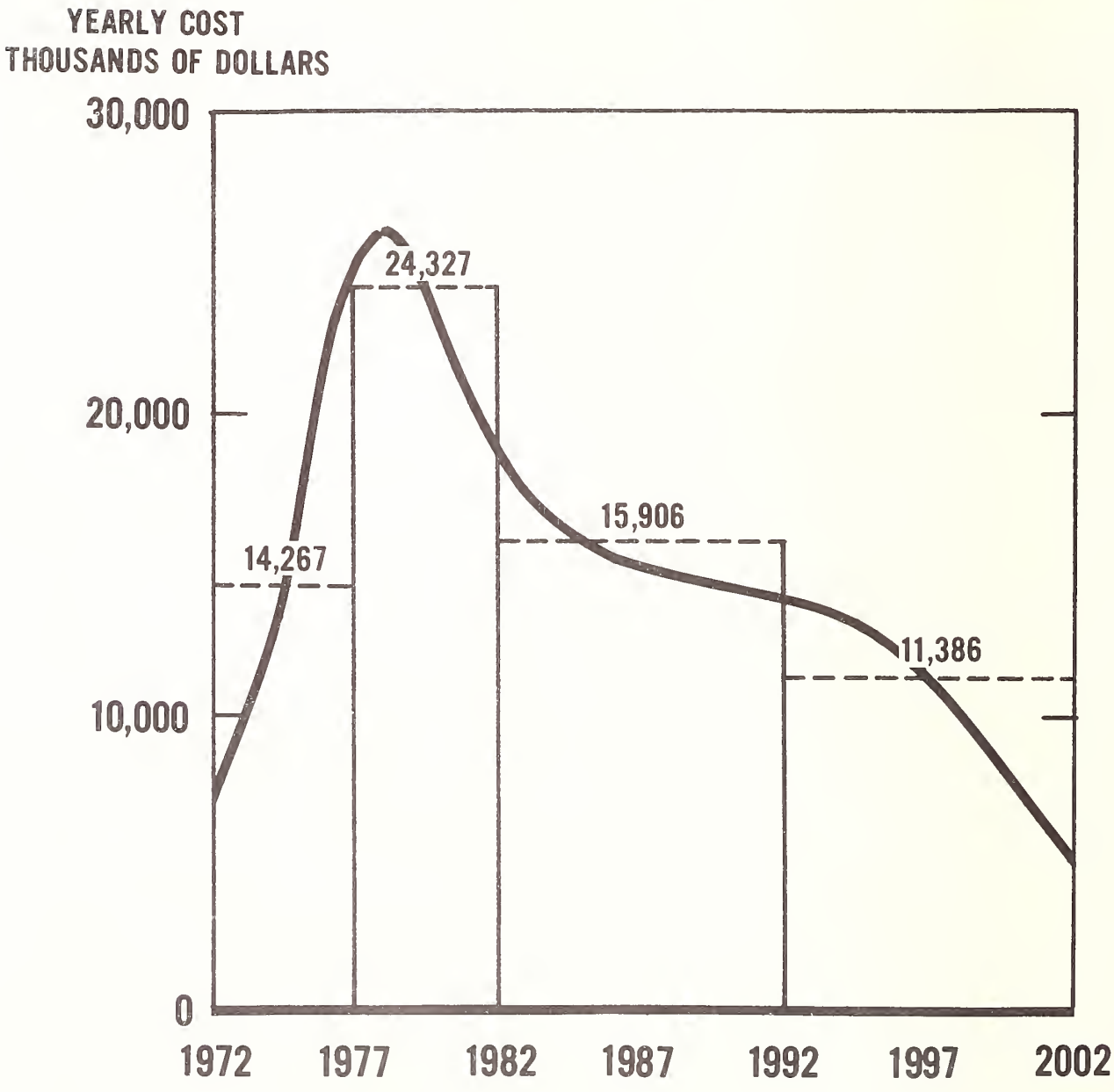


FIGURE 5

RESEARCH, DEVELOPMENT, TEST & EVALUATION
CUMULATIVE COSTS OF METRICATION

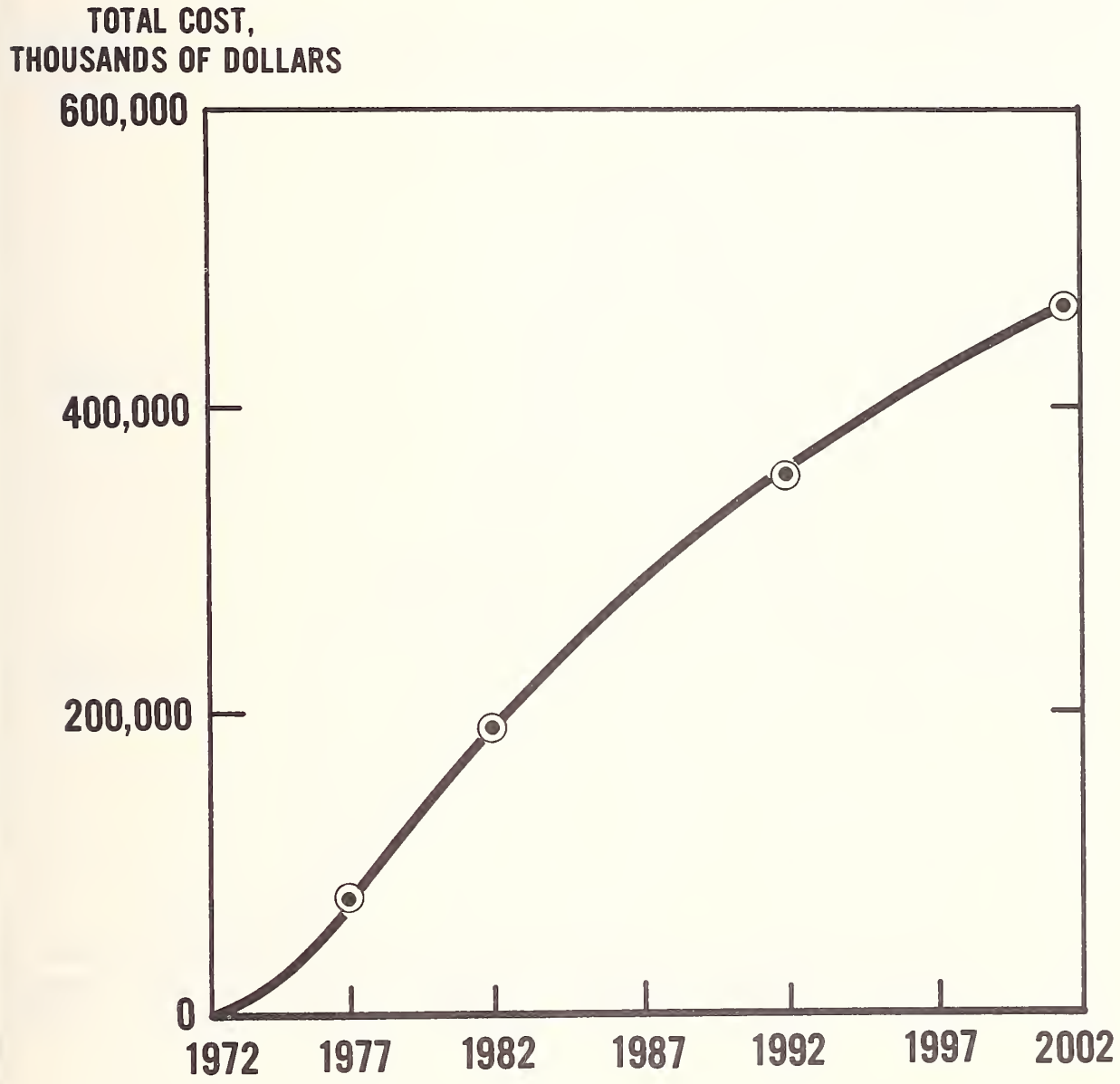


FIGURE 6

PROCUREMENT OF EQUIPMENT & MISSILES
METRICATION COST PROFILE

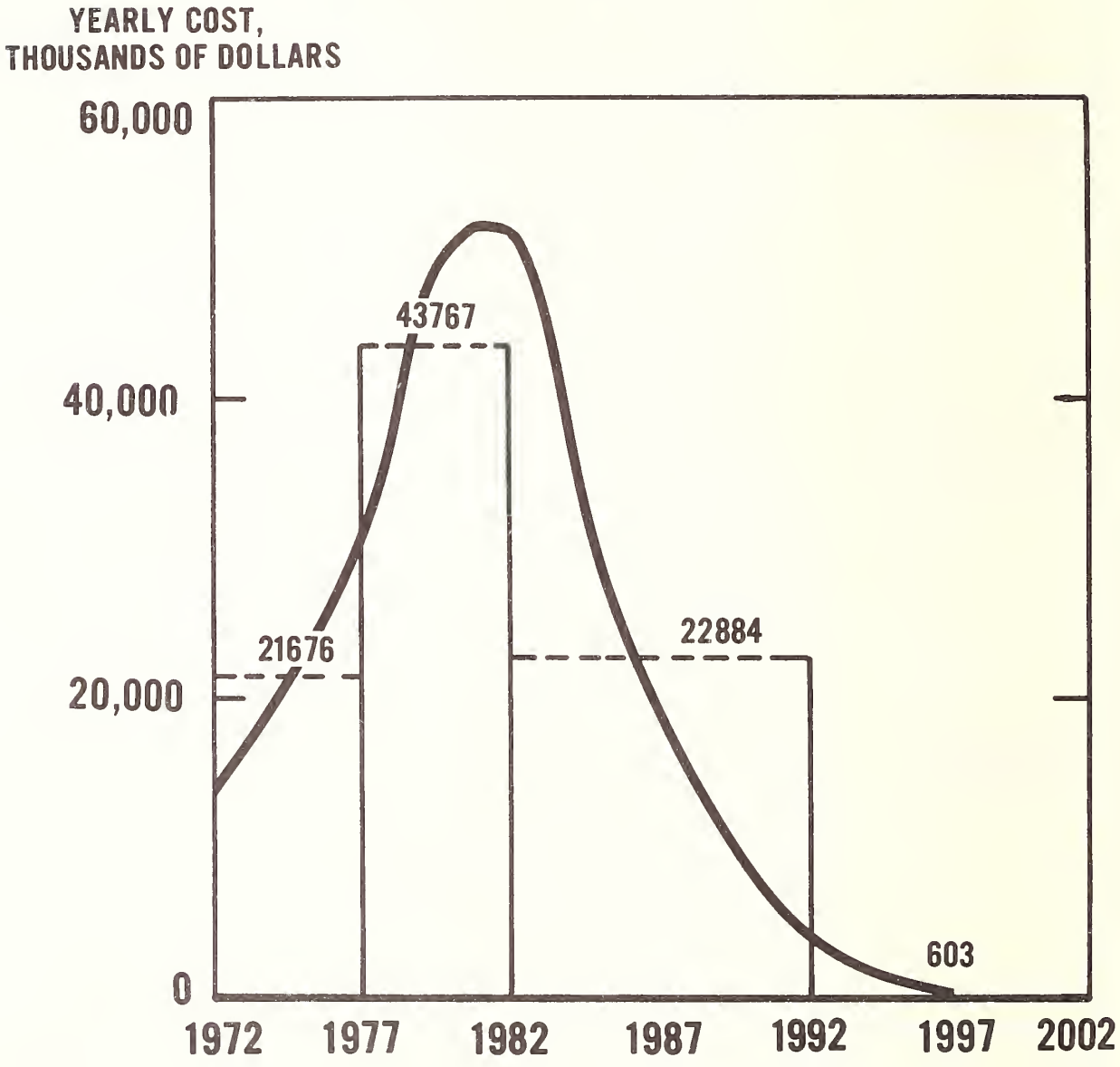


FIGURE 7

PROCUREMENT OF EQUIPMENT & MISSILES
CUMULATIVE COSTS OF METRICATION

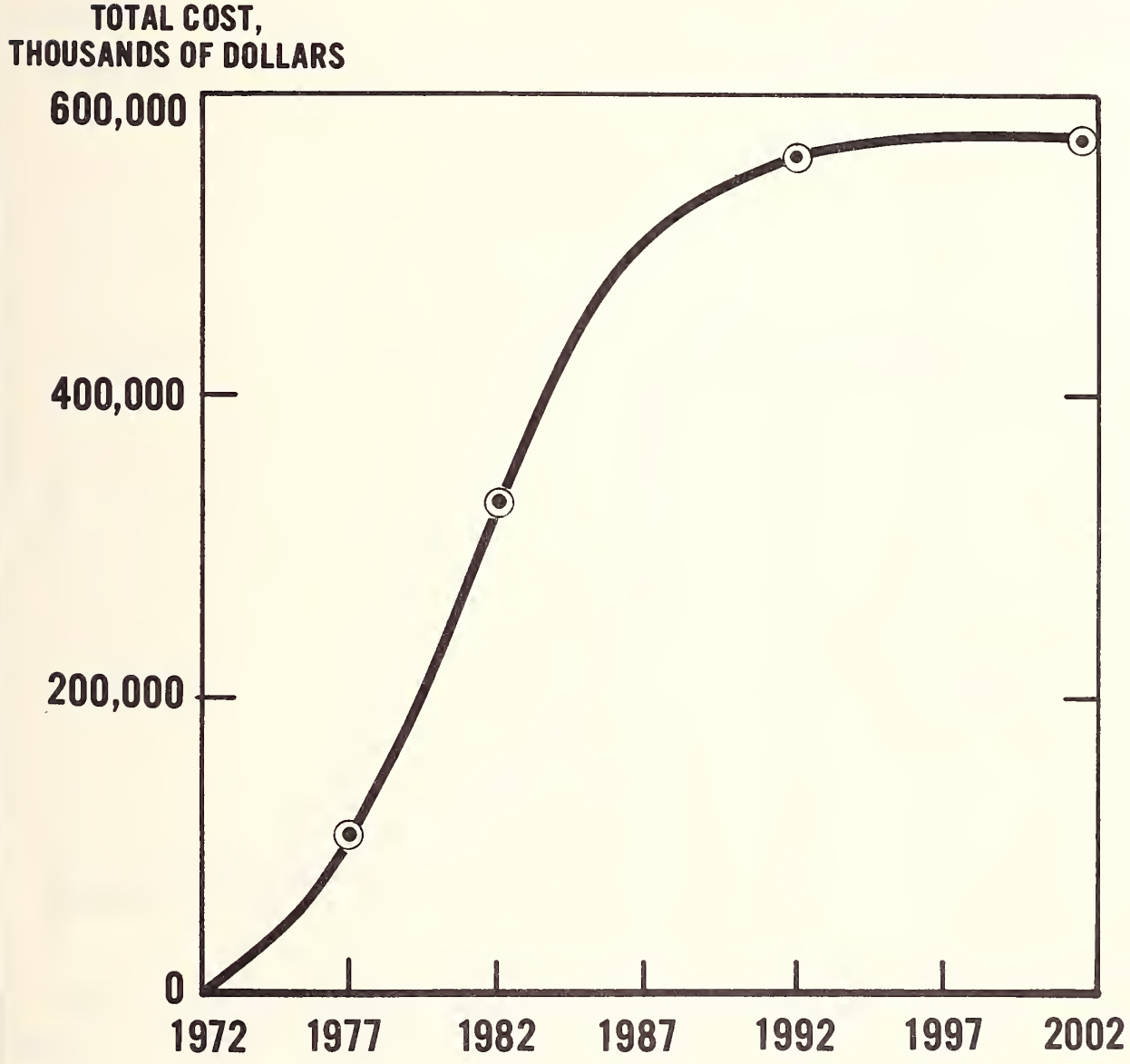


FIGURE 8

MILITARY CONSTRUCTION, ARMY
METRICATION COST PROFILE

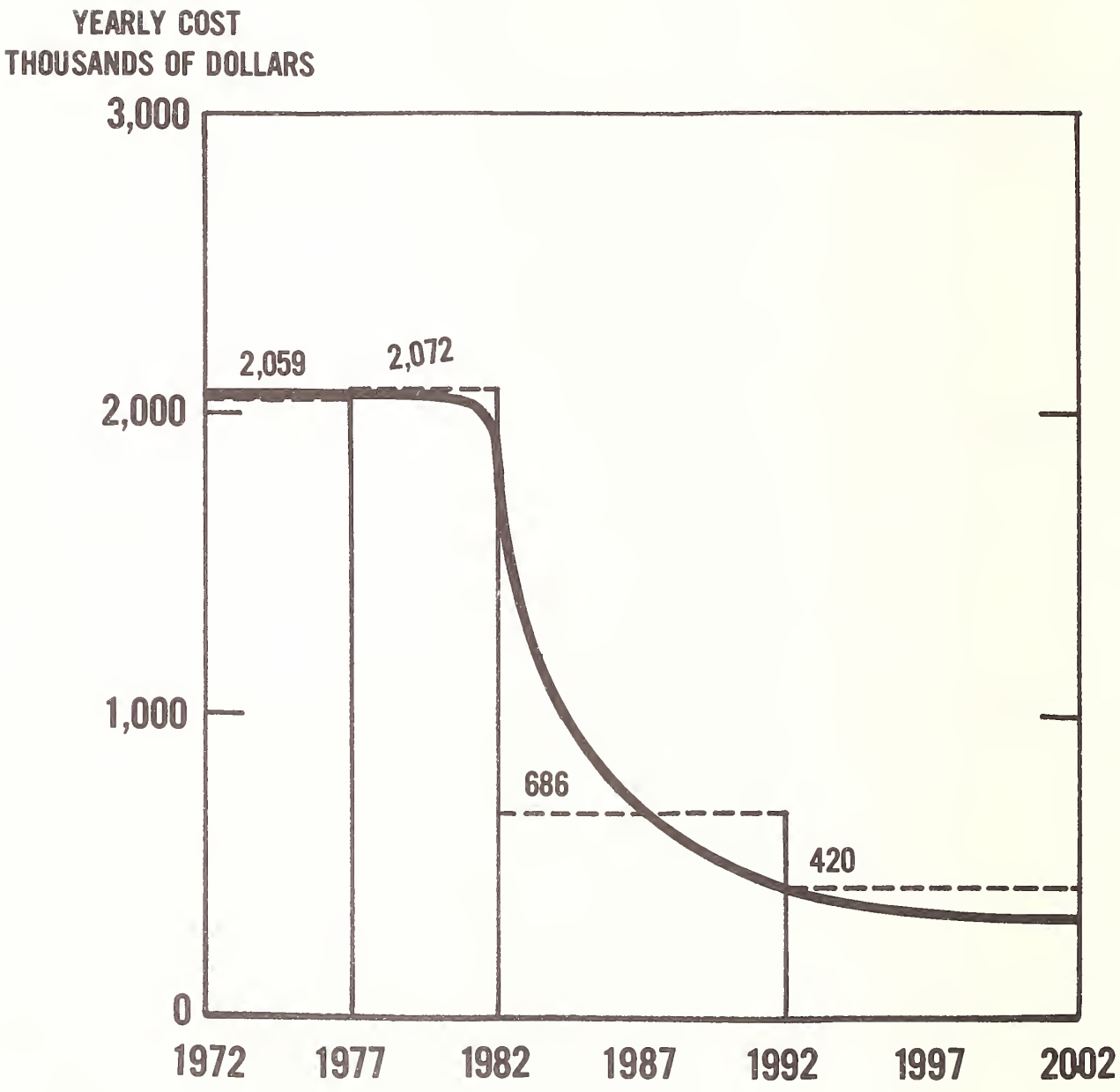


FIGURE 9

MILITARY CONSTRUCTION, ARMY
COSTS OF METRICATION

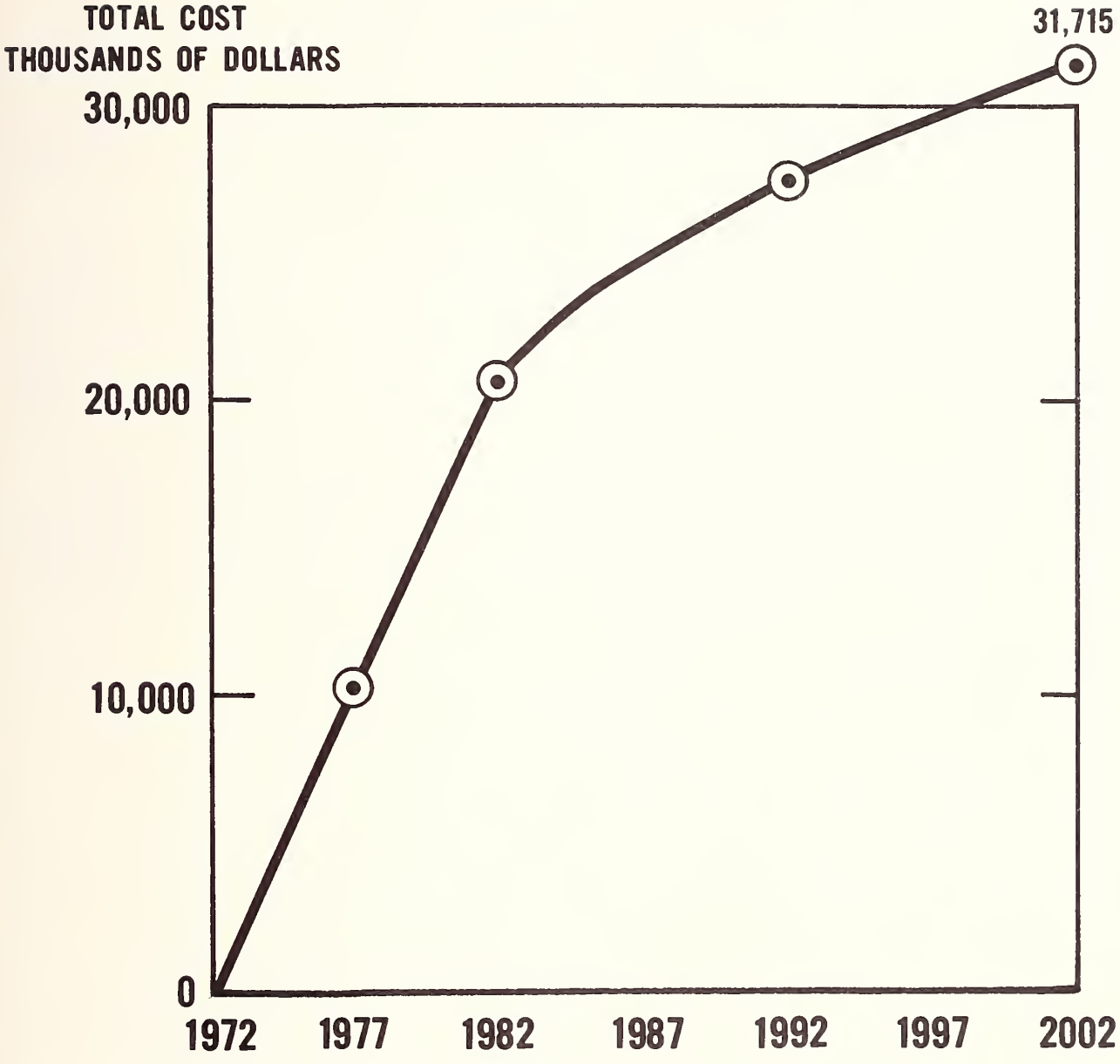


FIGURE 10

NAVY COST ESTIMATES

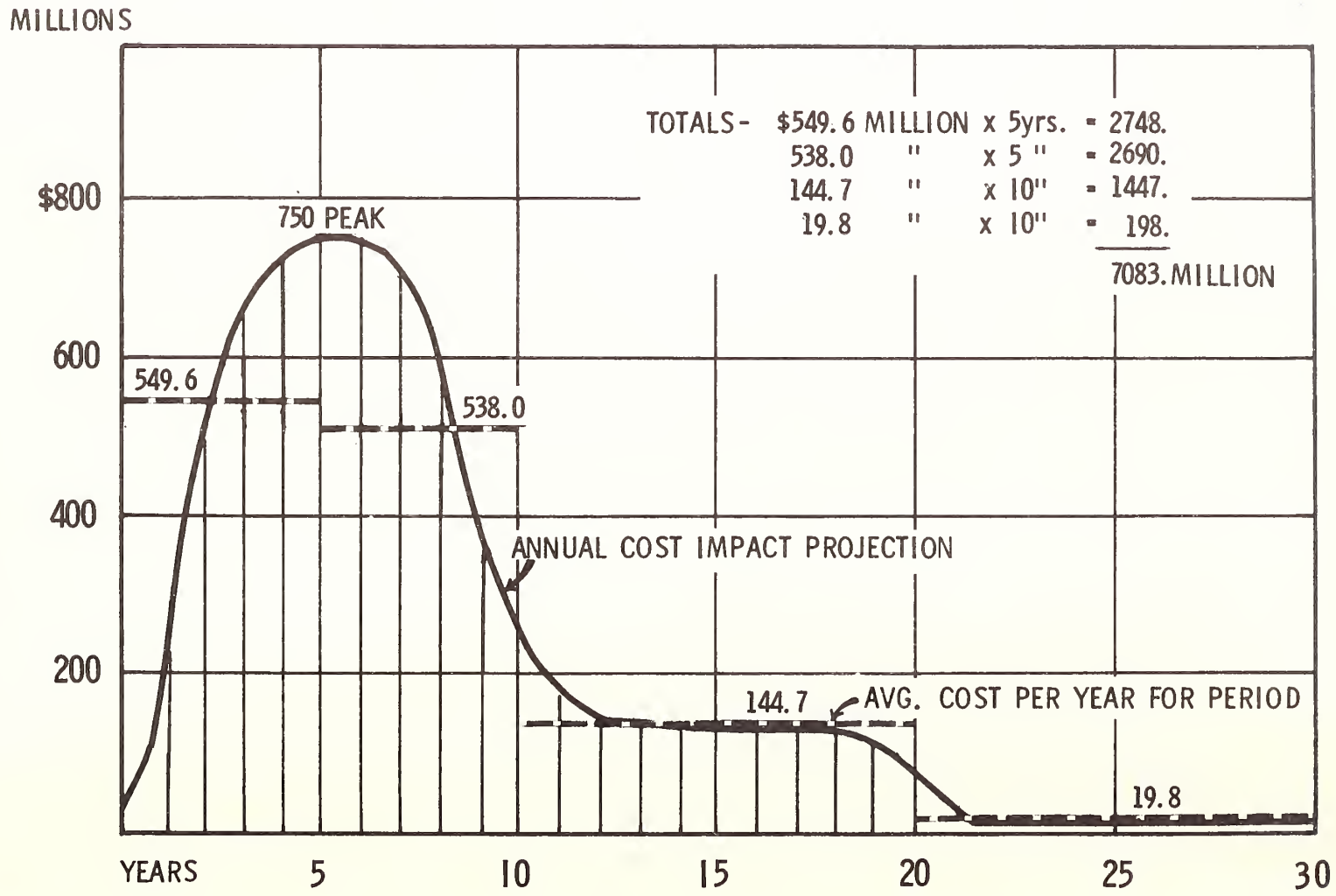
The added cost to maintain constant mission capability while adopting the metric system is estimated to be $7.08 billion. This cost impact is based on the assumptions set forth in Appendix B of this report and extends over a 30-year period. It includes estimates for hardware procurement and changeover for resources to support an estimated 96,000 man-years of effort. The major cost impact would peak in the first ten years when design standards would be changed and incorporated into new systems design. The peaked requirements are realistic since it is anticipated that the changeover period would be compressed to assuage long term disruption associated with operating dual systems (metric and customary).

The cost estimates contained herein do not include increased cost of "off-the-shelf" type items/equipments. The guidelines for the DOD study stated that the Department of Commerce will project such costs. Those costs could be significant and represent a general surcharge applied by the manufacturers to their complete lines of products to retrieve the overhead type costs encountered in their engineering departments and machine shops for changeover to the metric system. Such a surcharge (the extent of which is unknown at this time) would undoubtedly be borne by the DOD and therefore represents an additive budget requirement.

To preclude duplication, the cost impact estimates have been developed along the lines used in development of the Navy's budget. The fleets were instructed to exclude certain costs which could, possibly, have been duplicated by the shore establishment. Also, the costs at naval activities that operate on the industrial funding concept (where customer pays cost of job) were reviewed to preclude duplication.

NAVY

METRIC SYSTEM STUDY
COST IMPACT



METRIC SYSTEM STUDY COST IMPACT STATEMENT

(Millions of $)

Appropriation	FY 1970 Budget	Cost Increases Due to Metrication								Totals
		1972-1977		1977-1982		1982-1992		1992- ----		
		Dollars[1]	%[3]	Dollars[1]	%[3]	Dollars[2]	%[3]	Dollars	%[3]	
O&MN (Operations & Maintenance)	4067.8	648.5	3.2	1255.7	6.2	831.8	2.0	179.0	-	2915.0
RDT&EN (Research & Development)	1747.7	159.2	1.8	117.6	1.4	57.5	.3	-	-	334.3
SCN (Ship Construction)	2631.7	1170.7	8.8	585.8	4.4	211.4	.8	-	-	1967.9
PA&MN (Procurement of Aircraft & Missiles)	2843.9	9.3	.1	65.9	.1	66.4	-	-	-	141.6
OPN (Other Procurement)	2040.1	394.8	3.9	261.7	2.6	145.9	.7	-	-	802.4
MILCON (Military Construction)	336.2	4.9	-	14.7	-	10.7	-	-	-	30.3
NSF (Naval Stock Fund)		165.0	-	165.0	-	-	-	-	-	330.0
Navy Sub-total		2552.4		2466.4		1323.7		179.0		6521.5
USMC (Marine Corps)		195.1		223.6		123.8		18.8		561.3
Totals		2747.5		2690.0		1447.5		197.8		7082.8 GRAND TOTAL

NOTE: [1] Dollars shown represent cost increase for 5 year period.
[2] Dollars shown represent cost increase for a 10 year period.
[3] % of FY70 budget which annual average represents.

AIR FORCE COST ESTIMATES

The major financial impacts of converting to metric measurements will involve additive costs associated with the areas of design, development, procurement and support of new weapon systems, publication of technical data, training of personnel, and storage generated by metrication. Such additive costs were computed or estimated by the appropriate Air Force organization. It must be emphasized that the estimates were based on many variable factors, some of which are outside the purview of Air Force control. For example,

The assumption was made that parts would be available in either system at no cost penalty. This is not entirely realistic because the availability of metric components early in the changeover and the availability of customary units later on will undoubtedly be limited. This supply shortage most likely will dictate a premium price over and above add on costs associated with normal business amortization of "metric start-up" costs. However, until a master plan for metrication is adopted, and the interrelationships caused by the implementation of the plan are known, this factor cannot be evaluated or costed with any degree of accuracy.

The cost attached to mistakes made by operating personnel due to "metric mix-ups" was not estimated. A mechanic picks up the wrong type bolt and ruins a part in his attempt to force it to fit. A training aircraft and crew is stranded for an extra 24 hours after an emergency landing because the wrong replacement part for the engine was flown in to them. The crew bringing it must make an extra trip to provide the correct size part. A SAC mission is aborted and an expensive overhaul necessitated because the wrong part was installed and seemed to fit until take-off power was applied. A fighter aircraft is lost from a similar malfunction, not discovered until in flight. Hundreds and thousands of delays, minor and major, will occur - they are bound to. No amount of careful training is now able to eliminate such problems as tools left in engines, wrong parts installed or incorrect procedures followed. It would be less than realistic to presume that the change to metric parts will not open up a whole new spectrum of such mistakes. ATC and the operating commands have recognized this error potential in their assessment of the metric impact. They must do all that is physically possible to pinpoint and eliminate the chance for such errors but they will never be able to completely eliminate them.

The costs were developed as percentages of the FY 70 President's Budget and thus are in 1970 dollars, no inflation factor is applied. If the current 4.2% rate of inflation is projected over the 10-year period, and 1/10th of the costs spent each year, a little over $300 million additional cost will be generated by this factor. This cost is not included in those shown on the cost summary table.

The cost as determined by the design and development function, notably Air Force Systems Command (AFSC) has been subdivided into two areas for estimating purposes and are added costs. In-house costs will require a 2.1% increase per year to maintain constant mission capability. Contractual costs of new systems will rise 10-50% per program depending on how far the acquisition process has progressed when the decision to "go metric" is made. This characteristic required that a different approach be used in developing the weapon systems costs. The impact was measured by determining which of the systems coming into the inventory could be reasonably converted to metric measurements. Previous studies within the Air Force Systems Command have shown that once a system is committed to production the cost penalty associated with conversion is too great to reasonably assume it would be directed. Thus such systems as A-7, F-4, and Minuteman were eliminated from consideration. It was found, however, that it would be possible to consider conversion for such systems as the B-1, SCAD, A-X, the tactical AGMX-3 and possibly the F-15. The impact upon these and other potential candidate systems was found to fall into four general areas:

First Contract, no Preliminary Design, With Competition - Up to 10% increase over previous similar contracts with delay of one to three months primarily for training and experimental testing to insure smooth transition.

Contract Awarded and Preliminary Design Completed - Up to 20% increase in cost of original contract with delay of three to four months. This will include training, experimental testing and the noncompetitive factor.

Contract with Detail Drawings Complete for Fabrication of Test Articles - Up to 30% increase in cost of original contract with delay of six months. At this point, many of the parts that make up an assembly have been procured or fabricated.

Contract with Development Testing Completed, Configuration Accepted by Government and Production Starting - Up to 50% increase in cost of original contract with delay of 9 to 12 months. This includes cost of repeat testing. It also includes cost of converting all data which at this point is also ready for production. It does not include cost of production parts that must be discarded or converted.

The weapon system candidates were sorted into the appropriate categories and the cost impact for each generated as a percent of their R & D funds. These systems, which have a total R&D cost of a little over $7 billion yielded a conversion cost of about $1.3 billion. No cost increase was associated with production funds although any production delay will likely cause a cost increase. The portion of R&D funds used for personnel pay and support (about $460 million a year) was estimated to require about $96.5 million for the 10-year period utilizing the average percentage impact factor which was developed for AFSC and other major command personnel costs. Lastly, a factor of 3.5% was applied to the balance of costs (about $1.8 billion per year). This factor is believed representative of the magnitude of the impact on the remaining Air Force development areas.

The logistics area will be affected by complex conversion problems. Efficient operations and maintenance of weapon systems require that personnel deal with aircraft and other systems as hundreds of thousands of discrete parts. Moreover, they will react to, rather than initiate metric conversion. AFLC will have to coordinate the impact of manifold individual decisions during the metric changeover period. They will have to translate SPO decisions into terms of spare parts stockage and maintenance manpower requirements in all field operations and depots for which they have responsibility. They must assume that trained maintenance labor, tools, and spare parts are available to support established weapon system in-commission rates. They must procure both metric and conventional parts and provide warehouse space for the increased storage requirements of these parts. Their cost estimate reflects the cost impact first on their operating budget and second on all other AFLC costs. They estimate that for the first five years their operating costs will increase annually about 1.7 % due to metrication, and that the comparable costs will rise about 2.4% per year for the second half of the conversion period. This produces a total cost of approximately $600 million. Costs affecting their other budget areas are estimated to require about the same percentage increase and generate a cost of about $400 million, or a total impact on AFLC for the ten-year period of just over $1 billion. In addition to these costs, the study found that there will be items requiring dual stockage and maintenance for weapon systems with an effective life beyond 1982. For the various AFLC areas this impact will range from under 1% to almost 3%. The average impact will be about 1% per year, or a cost of about $25 million per year for at least the next ten years. This cost is in addition to the $1 billion already estimated for AFLC. Caution must be exercised in the metric conversion to avoid costs in excess of these estimates. For instance, procurement of conventional parts during the latter part of the 10-year conversion must be made in advance of actual requirements in order to

avoid the cost premiums associated with re-tooling and set-up for conventional parts from a company which has already "gone metric." It is even possible that some conventional equipment could be forced into premature obsolescence by the nonavailability of replacement parts or the high cost of acquiring these parts. The area of materials handling equipment is another which requires careful planning. The AFLC costs are based upon the assumption that all such equipment will be retained for the duration of its useful life. If, however, standard cargo containers are replaced by metric containers which cannot be handled by current equipment, a cost penalty would result from the forced procurement of such new equipment and the waste of the residual value of the conventional items. Close coordination between AFSC and AFLC will be necessary in order that the total cost impact of a decision to proceed with metrication may be assessed prior to the decision being made. AFLC must know, in sufficient time to procure long-lead time items, arrange for storage space, etc., when metric units are introduced into the inventory.

In the facilities construction and maintenance area, the directly attributable costs are anticipated to increase the military construction budget by 1.2% during the transition period. The major financial impacts of converting to metric measurements will involve additive costs associated with the areas of maintenance of existing facilities with life cycle of more than 30 years, publication of technical data, training of personnel, and storage generated by metrication. Costs include the updating of as-built and record drawings and reports; the procuring and/or altering of hand tools and measuring devices; the revamping of bench-stock storage to provide both metric and inch-pound materials; the conversion of technical specifications, production of additional specifications, and maintenance of changes and publications; and the conversion of master plans and real property records.

During the conversion period an increase in manpower resources will be required to conduct training programs, as well as safety surveys, to insure the increased accident potential brought about by the new system is kept to a minimum Air Force-wide. Productivity will be reduced during the training period and more personnel will be required to maintain present output in some cases. Evaluation leads to the conclusion that one of the major financial impacts of converting to the metric system will involve costs associated with the training of personnel. Air Training Command (ATC) would logically have the primary task of reworking training manuals and programs to orient personnel toward use of the metric system. The operational commands would probably emphasize follow-on training during the transition period when both metric and inch-pound systems are in effect. Financial analysis indicates an average of approximately $10.8 million yearly increase in the ATC budget would be required to maintain mission effectiveness during conversion. This annual sum equates to approximately 1.2% of the ATC operating budget. This figure does not include funds for construction of new storage facilities which will be required.

In addition to the aforementioned commands, the cost inputs from all other commands and activities were examined to assure that a reasonable assessment of the metrication impact had been made and that the costs were not duplicated. In addition, the dollar impact was converted to a percentage of the FY 70 President's Budget, as published in the 26 January 70 Force and Financial Plan. This assures that the relative impact upon each major command was measured from a common baseline. The Commands tended to group in three major categories. The first generated a minimum cost impact. Such commands as the USAF Security Service (USAFSS) and the Data Systems Design Center (DSDC) fall into this category. Second were Commands requiring, in addition to training, some degree of hardware and/or supplies replacement; Air Force Communications Service (AFCS) and the Air Academy are examples of this group. The last area included cost impact of such specialized items as dual stockage and warehousing of parts for AFLC, increased development costs of AFSC, and the heavy training load which will fall upon ATC.

The individual commands generated variances in their individual costs which were the result of estimating technique variance rather than actual differences between commands. In order to minimize variances caused by estimating technique, the costs were projected for the final report by group rather than by individual command. In addition, the use of the President's Budget as the baseline for the commands assures that no costs have been duplicated. The Research and Development costs were handled separately. The problems, and thus the costing methodology for Research and Development are unique. This area was handled by examining the currently projected weapon system mix over the next ten years as a whole to determine the impact on this area. The Research and Development effort was divided into the areas of weapon systems currently approved to phase into the inventory during the 1970's; in-house personnel pay; support paid for by R&D funds; and all other research programs.

The estimated total cost is shown in the following Cost Summary Table.

AIR FORCE COST SUMMARY TABLE

IMPACT OF METRICATION
($ MILLIONS)

	FY 70 PRES BUDGET	ANNUAL COST	10-YEAR COST
MINIMUM IMPACT	(LESS THAN 1%/YEAR)		
USAFSO	$ 37.889		
USAFSS	230.634		
DSDC	6.007		
AF RES/ANG	673.369		
OTHER	13.564		
SUBTOTAL	$ 961.463	$ 7.210	$ 72.000
MINOR IMPACT	(LESS THAN 2%/YEAR)		
AIR ACADEMY	$ 57.364		
ADC	762 .124		
MAC	878.953		
AFCS	314.217		
OTHER	2,042.759		
SUBTOTAL	$ 4,055.417	$ 60.830	$ 608.000
SIGNIFICANT IMPACT	(2%/YEAR OR MORE)		
AFLC	$ 5,278.895		
USAFE	569.579		
ACIC	58.674		
ATC	1,131.740		
AFSC (LESS R&D)	3,868.453		
SAC	1,729.955		
TAC	1,034.583		
OTHER (LESS R&D)	2,692.432		
	$16,364.311	$343.644	$3,436.000
WEAPONS SYSTEM ACQUISITION (RESEARCH AND DEVELOPMENT APPROPRIATION)			
MAJOR WPNS SYS	$ 3,080.588		$1,258.000
OTHER			730.000
SUBTOTAL			$1,988.000
10 YEAR METRIC IMPACT ESTIMATE			$6,104.000
10 YR FOLLOW-ON COSTS (O&M FOR LONG ITEMS)			250.000
TOTAL CONVERSION COSTS			$6,354.000

DEFENSE SUPPLY AGENCY COST ESTIMATES

The impact of converting to the metric system on Defense Supply Agency (DSA) falls primarily into the functional areas of procurement, supply support, technical data, installations and services, and personnel and training. Consequently, the measurement of the impact is in terms of the added costs to accomplish the conversion while maintaining mission capability.

The additional DSA costs will result primarily from the requirement for "dual stockage" of inventories during the conversion period. This involves the need to continue the support of major end items of customary inch-pound equipment until the economic retirement point is reached, while introducing similar major end items of metric equipment requiring support with metric repair parts and components. Accordingly, it is estimated that the supply system growth or increase in DSA inventories will peak at approximately 25% and that the cost to introduce, manage, and stock the additional inventory will approximate an estimated $142.2 million for the 10-year period of conversion phased as follows:

Year	% Increase	Materiel Management (Millions)	Storage (Millions)
1st	10%	$ 3.4	$ 4.5
2nd	20%	6.8	9.0
3rd	25%	8.5	11.25
4th	25%	8.5	11.25
5th	25%	8.5	11.25
6th	25%	8.5	11.25
7th	20%	6.8	9.0
8th	15%	5.1	6.75
9th	10%	3.4	4.5
10th	5%	1.7	2.25
		$61.2	$81.00
	TOTAL		$142.2

Enclosure 1 graphically portrays the supply system growth in terms of percentage of increase by year in relationship to inventory line items.

Procurement costs to support the acquisition of the increased number of line items as depicted in Enclosure 1 are estimated at approximately $63 million for the 10-year conversion period. This cost is equated to the yearly increase in inventory line items as projected above.

It is anticipated that there will be an impact on Installations and Services to accommodate the increased inventories, in terms of Base Supply, Transportation and Traffic Management, and Modification or Replacement of Real Property. This is estimated to approximate $3.1 million for the 10-year conversion period (see Enclosure 2).

There will be added costs in the area of cataloging and standardization involving conversion of all Federal Stock Catalogs to reflect the metric system of measurement with the attendant standardization effort. This is estimated to approximate $2.8 million for the 10-year conversion period (see Enclosure 3).

Personnel training, for the most part, can be accomplished without additional cost during the 5-year preparatory period using in-house capability. For example, the DSA Contract Administration Services organization which encompasses approximately half of the total DSA work force has identified the number of mandays of training required, and considers it within in-house capability (see Enclosure 4).

There will be added costs in other sub-program areas of Command and Support such as Accounting and Finance, Civilian Personnel, etc. which are estimated to approximate .5 million per year for the 10-year conversion period. (See Enclosure 5)

Attached as Enclosure 6 is a recapitulation of the cost impact on DSA. This sets forth the percentage of increase over the DSA FY 70 budget expenditures at an average of approximately 3.2% per year.

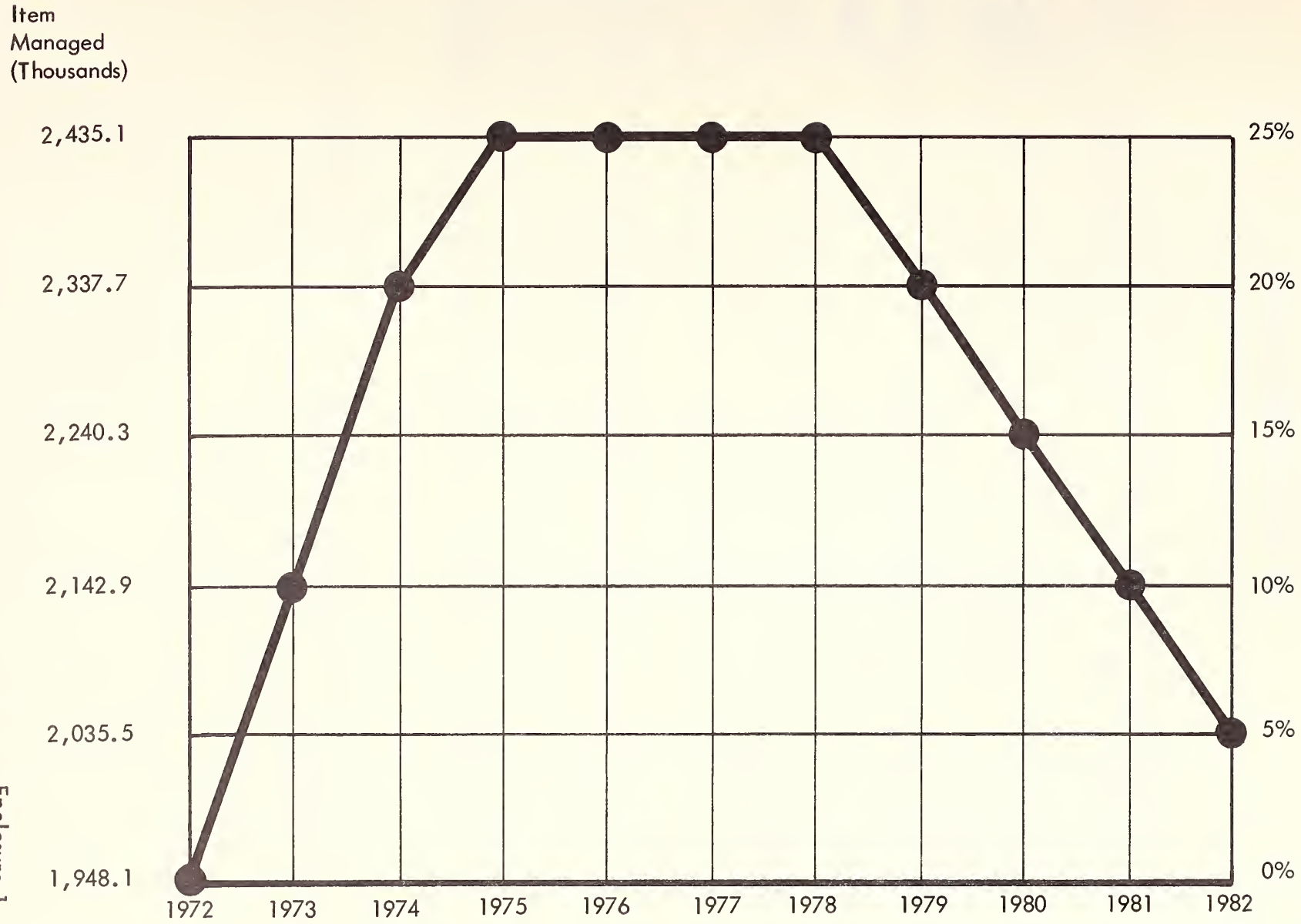
For the purpose of this report, Industrial Plant Equipment (IPE) is treated as a special topic. With respect to IPE, for which DSA has cognizance, a special study was conducted to determine the impact of converting metal working equipment to accommodate the metric system of measurement. This could involve either total replacement of equipment or modification of existing equipment. The study reveals that of the total inventory of government owned metal working equipment (see Enclosure 7) only 31% of the items would require conversion to the metric system of measurement. Metal forming equipment, and other types of metal working equipment that are adaptable to the metric system without conversion constitute the remaining 69% of the current inventory.

The existing inventory of metal working equipment, with the exception of a relatively small number of items which are owned by DSA or are in "Idle Reserve," are owned by the Military Departments as shown in Enclosure 7. Therefore, the costs to replace or modify existing equipment cannot be assessed as a DSA cost impact, since DSA does not have responsibility for requirements determination, procurement or budgeting for IPE. Replacement/modification costs for IPE would be borne by the Military Departments, except for those items owned by DSA, and those items reverted to "Idle Reserve."

A 5-year phase-out program of government owned IPE in contractors plants is scheduled, upon passage of legislation (negotiated sales law) by Congress. It is assumed for the purpose of this study that the legislation will be passed in 1971. An analysis of the 5-year phase-out program (see Enclosure 8) identifies the decrease in government owned IPE inventory. This reduction in government owned IPE will correspondingly decrease the cost to DOD of converting IPE to the metric system of measurement.

Taking into consideration the 5 year phase-out program, and the estimate that only 31% of the government owned metal working equipment inventory would require conversion to the metric system of measurement substantially decreases the cost impact on DOD in the IPE area. The net cost impact for complete replacement of equipment would approximate $37.4 million per year for the 10-year conversion period, while modification of equipment would approximate $11.5 million per year over the 10-year period. Enclosure 9 sets forth the detailed breakdown of this cost impact on the Military Departments and DSA. It is considered that modification of equipment rather than total replacement would be the most logical and economical course to pursue.

SUPPLY SYSTEM GROWTH



Enclosure 1

ESTIMATED METRICATION COSTS

INSTALLATIONS AND SERVICES

PROGRAM	CODE	FY 70 BUDGET*	COST INCREASES			
			72-76		77-81	
			%**	$	%**	$
Transportation and Traffic Management	P-500	7.4	2.6%	.950	2.6%	.950
Base Supply	P-926	4.5			2.2%	.487
Modification or Replacement of Real Property	P-930	7.7	.65%	.250	1.3%	.500
TOTALS				1.200		1.937

Enclosure 2

* All Dollar figures are in millions

** Annual percentage increase over FY 70 Budget.

ESTIMATED COST IMPACT

P-400

O & M (DIRECT PROGRAMS)	FY 1972		FY 1973		FY 1974		FY 1975		FY 1976	
	$ (000)	%	$ (000)	%	$ (000)	%	$ (000)	%	$ (000)	%
OTHER DIRECT PROGRAMS										
Cataloging	---	---	---	---	---	---	326.6	2.0	326.6	2.0
Standardization	2.0	.02	2.0	.02	2.0	.02	2.0	.02	2.0	.02
TOTAL O&M COSTS	2.0	.02	2.0	.02	2.0	.02	328.6	1.4	328.6	1.4
MANYEARS	---		---		---		32		32	
DOLLARS	2.0		2.0		2.0		328.6		328.6	

O & M (DIRECT PROGRAMS)	FY 1977		FY 1978		FY 1979		FY 1980		FY 1981	
	$ (000)	%	$ (000)	%	$ (000)	%	$ (000)	%	$ (000)	%
OTHER DIRECT PROGRAMS										
Cataloging	556.3	3.4	393.0	2.4	393.0	2.4	393.0	2.4	393.0	2.4
Standardization	2.0	.02	2.0	.02	2.0	.02	2.0	.02	2.0	.02
TOTAL O&M COSTS	558.3	2.3	395.0	1.6	395.0	1.6	395.0	1.6	395.0	1.6
MANYEARS	60		44		44		44		44	
DOLLARS	558.3		395.0		395.0		395.0		395.0	

Enclosure 3

DSA CONTRACT ADMINISTRATION

1. The training requirements throughout the DSA Contract Administration for conversion to the metric system are estimated at approximately 10,000 mandays. This training effort is considered to be within in-house capability, and no additional personnel would be hired to conduct the training. In addition, conversion to the metric system would not impact on any equipment (testing or operational) currently owned by the DSA Contract Administration field activities.

2. Personnel concerned with contract administration will be trained during the Preparatory Period to recognize the metric units that will commence appearing in procurement contracts. It is anticipated that this training will begin on 1 July 1972 and be completed by 1 January 1973.

Enclosure 4

COMMAND AND SUPPORT

(Excluding P-926 and 930)

PROGRAM	COST INCREASES $ (Millions) 72-76	77-81
P-900 (Finance and Accounting, Civilian Personnel, etc.)	.250	.250

Enclosure 5

- CONVERSION TO METRIC SYSTEM -

RECAPITUALTION OF COST IMPACT

ON

DSA

MILITARY APPROPRIATION STRUCTURE - PRESIDENT'S BUDGET FY 1970	DSA ACTUAL EXPENDITURES - FY 70 (Thousands)	AVERAGE COST IMPACT PER YEAR (Thousands)
P-100 Procurement	35,468	$ 6,330
P-200 Materiel Management	33,510	6,120
P-300 Depot Operations	108,499	8,100
P-400 Logistic Services	50,346	280
P-500 Transportation Services	7,458	370
P-600 Contract Administration Services	246,346	0
P-800 HQ and Central Activities	34,804	0
P-900 Command and Support	170,252	624
TOTALS	$ 686,683	$ 21,794

Average percent of yearly increase over 10 year period = Approximately 3.2%

Enclosure 6

GOVERNMENT OWNED
INDUSTRIAL PLANT EQUIPMENT (IPE)
(METAL WORKING EQUIPMENT)

Ownership	Active (In-Use)				Packages, Standby Lines & Active Base Packages (Defense Industrial Equip. Reserve)		Idle Reserve (In-Store)	
	Contractor Facility		Govt. Facility					
	Items	Value (000)	Items	Value (000)	Items	Value (000)	Items	Value (000)
Army	22,243	$362,112	17,942	$195,711	17,894	$312,562		
Navy	11,212	242,509	28,891	296,020				
Air Force	24,541	703,759	13,859	101,966				
DSA	716	9,214	720	9,481			9,104	$151,167
TOTALS	58,712	$317,594	58,412	$603,178	17,894	$312,562	9,104	$151,167

Total Metal Working Equipment *

Items - 144,122 . . . Value (000) - $2,384,501

* Of the total government owned IPE inventory (metal working) only 31% would retire conversion for purposes of metric system measurement. The remaining 69% include metal forming equipment, and other types of metal working equipment that are adaptable to the metric system without conversion.

Enclosure 7

ANALYSIS OF 5 YEAR PHASE-OUT PROGRAM

(METAL WORKING EQUIPMENT)

	ITEMS	VALUE (000)
Contractor Facilities (Active - In-use)	58,712	$ 1,317,594
Less		
Special Lists (Classified)	- 1,317	- 7,000
Non-Profit Organizations	- 2,572	-77,000
Possible Negotiated Sales to Contractors	54,823	$ 1,233,594
Estimate 60% Buy by Contractors	32,893	$ 740,156
Estimate 6% to Idle Reserve	3,289	74,016
Estimate 32% to Disposal	18,641	419,422
TOTALS	54,823	$ 1,233,594

Enclosure 8

COST IMPACT
GOVERNMENT OWNED IPE
(METAL WORKING EQUIPMENT)

Ownership	ACTIVE (In-Use) Govt. Facility			Packages, Standby Lines & Active Base Packages (Defense Industrial Equip. Reserve)			Idle Reserve (In-Store)		
		* Cost (000)			* Cost (000)			* Cost (000)	
	Items	Replacement	Modification	Items	Replacement	Modification	Items	Replacement	Modification
Army	5,562	$ 7,564	$ 2,318	5,547	$ 7,544	$ 2,313			
Navy	8,026	10,915	3,347						
Air Force	4,296	5,843	1,791						
DSA	223	303	93				3,842	$ 5,225	$ 1,602

* Annual Cost Impact for 10 Year Conversion Period -

TOTAL 10 YEAR COSTS BY SERVICE/AGENCY

	* Replacement Cost (000)	* Modification (000)
Army	$ 151,080	$ 46,320
Navy	109,150	33,470
Air Force	58,430	17,910
DSA	55,280	16,950
TOTALS	$ 373,940	$ 114,650

* Replacement Cost Based on Estimated Figure of $13,600 per item (Acquisition Cost)

* Modification Cost Based on Estimated Figure of $ 4,170 per item (Acquisition Cost)

Enclosure 9

COST ESTIMATES

The percentage increase in current resources necessary to maintain constant mission capability during the 1972-1982 time period will be approximately .06 percent of the total budget. During the initial five-year period (1972-1977) the primary effort will be limited to retraining of personnel accompanied by the purchase of training aids, publications, and those hand tools and equipment required for training purposes. During the subsequent five-year period (1977-1982), the training costs will rise and equipment costs will increase to provide supplementary hand tools, machine tools, and increased spare parts inventory for the maintenance of dual equippage required during the changeover period. No increase in facilities or overall personnel resources will be required.

The financial impact of metrication during the period 1972-1992 will average approximately .038% of the DASA budget. All problems engendered by conversion from U.S. Customary units of measure to the Systeme International (SI) and monetary costs of the program can be largely absorbed within current training programs. No severe or insurmountable problems are expected during the transition period. Costs are expected to rise little more than nominally to offset training expenses of contractors, to defray the costs of using SI both in specifications and drawings, and to pay for closer supervisory control and inspections. Some small time delays are also expected. These, however, if time becomes critical, can be bought with heavier schedules.

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

APPROPRIATION: OPERATION AND MAINTENANCE

DEFENSE ATOMIC SUPPORT AGENCY

O&M	Estimated Cost Impact							
	1972-1977		1977-1982		1982-1992		1992- ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Intelligence & Communications								
1. Nuclear Weapons Operations	89,046	.085	208,738	.199	59,820	.057		
2. Training			3,825	.0036				
3. Counterintelligence and Investigative Activities								
Training, Medical and Other General Personnel Activities								
1. Hospitals								
Total O&M Costs	89,046	.085	212,563	.203	59,820	.057	0	0
Manyears Dollars	46,095	.044	95,508	.091	17,672	.017		
Fclty & Equip - Dollars	42,951	.041	117,055	.112	42,148	.04		

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

APPROPRIATION: PROCUREMENT DEFENSE AGENCIES

DEFENSE ATOMIC SUPPORT AGENCY

Procurement	Estimated Cost Impact							
	1972-1977		1977-1982		1982-1992		1992- ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Atomic Weapons Material								
Vehicles								
Other Capital Equipment								
Total Costs	0	0	0	0	0	0	0	0
Manyears Dollars								
Fclty & Equip - Dollars								

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

APPROPRIATION: RESEARCH, DEVELOPMENT, TEST & EVALUATION

DEFENSE ATOMIC SUPPORT AGENCY

RDT&E	Estimated Cost Impact							
	1972-1977		1977-1982		1982-1992		1992- ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Nuclear Weapons Effects Research	100,000	.018	100,000	.018	50,000	.009	0	0
Nuclear Weapons Effects Development								
Nuclear Weapons Effects Test	126,460	.023	126,460	.023	50,000	.009	50,000	
Total RDT&E Costs	226,460	.041	226,460	.041	100,000	.0175	50,000	
Manyears Dollars	202,160	.037	202,160	.037	100,000	.0175		
Fclty & Equip - Dollars	24,300	.004	24,300	.004				

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

APPROPRIATION: FAMILY HOUSING

DEFENSE ATOMIC SUPPORT AGENCY

Family Housing	Estimated Cost Impact							
	1972-1977		1977-1982		1982-1992		1992- ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Operation & Maintenance	16,396	.126	52,800	.410	58,455	.227	0	0
Total Family Housing Costs	16,396	.126	52,800	.410	58,455	.227	0	0
Manpower-Manyears Dollars	8,556	.066	27,457	.213	30,397	.118		
Fclty & Equip - Dollars	7,840	.061	25,343	.197	28,058	.109		

METRIC SYSTEM STUDY

COST IMPACT STATEMENT

APPROPRIATION: OTHER

DEFENSE ATOMIC SUPPORT AGENCY

Military Construction (Direct Programs)	Estimated Cost Impact							
	1972-1977		1977-1982		1982-1992		1992- ----	
	Dollars	Percent	Dollars	Percent	Dollars	Percent	Dollars	Percent
Major Construction								
Minor Construction								
Planning								
Total Mil Const Costs								
Manpower-Manyears Dollars								
Fclty & Equip - Dollars								
Military Personnel								
Total Mil Personnel Costs								
Manpower - Manyear Dollars								
Stock Fund								
Total Stock Fund Costs								
Other Appropriations								
Total Costs	0	0	0	0	0	0	0	0
Manyears Dollars								
Fclty & Equip - Dollars								

DEFENSE COMMUNICATIONS AGENCY COST ESTIMATES

No appreciable increase in resources will be required to maintain constant mission capability provided that a reasonable schedule for metrication is established. We believe that the increase in resources will be below the 0.01% cut-off figure.

The Defense Communications Agency (DCA) and its field activities are tenants on Army, Navy or Air Force installations at various locations. These activities are supported by and required to comply with the host's instructions which implement the appropriate military departments directives regarding such support. Accordingly, any impact of the metric system on the DCA will be directly proportional to the impact on the supporting military department; for example, in the case of host tenant agreements, any change in cost of a metric widget and its support to a military department will likely be transmitted to the Agency by the department concerned. Likewise major DCA systems and their support are provided by the military departments. The DCA is not in a position to predict the problems and costs which the metric system will cause the departments.

By conjecture it can be speculated that some inch-pound equipment may have to be attrited before completion of its useful life due to noncompatibility with ancillary metric equipment and supplies. For example, graphic reproduction equipment and supplies such as cameras, enlargers, film and sensitive paper, likewise inch-pound tools and measuring devices.

A number of DCA projects are for communications facilities leased from the common carriers, and therefore the impact of changing to the metric system could be determined only by asking the common carriers to do a detailed study.

Various data files produced and updated by DCA contain nonmetric measurements, and conversion would have to be made. Preliminary estimates are that there are approximately 50 data fields accessed and updated by 25 computer programs that would require conversion. These conversions could be done manually by changing each individual record, or it could be programmed at a cost of not less than 1 man year of effort. This would be a one time cost and there would be no continuing impact. Cost should be tabulated under Operation and Maintenance for the period 1972-1977.

The total cost for converting the data files and/or computer models of the National Military Command System Support Center in the Pentagon is estimated at $775,278. This is based on the assumption that metric system conversion work had been accomplished by other organizations such as the Defense Supply Agency or Assistant Secretary of Defense Installations & Logistics and that documentation, tools, and supplies would be furnished in the metric system prior to implementation.

At the Defense Commercial Communications Office (DECCO), all statistical data expressed in monetary units will be unaffected. These data represent the bulk of the daily operating measurements and specifications and the historical data in their files. One area of specifications and measurement which will be affected is that of mileage data concerned with circuitry. Conversion of miles to kilometers presents no major problem or significant effort and will not affect mission capability. However, DECCO metrication must interface with that of the commercial communications industry since rates and tariffs are established on the basis of miles which must be converted to kilometers.

The maintenance of communications equipment does not impose any severe logistical problems within Europe; however, U.S. logistical and manufacturing problems are foreseeable. Presently, most of the parts are still being manufactured in Europe and may be classed as off-the-shelf items. In the majority of our geographical areas, the equipment

has long been in operation geared to the metric system, to advantage. This equipment basically was inherited from the military components, some of which does not meet DCA standards but is doing the job in today's European Defense Communications Systems (DCS) to a large degree. Since the metric system is in use within the area, the gradual transition to the proposed metric system for U.S. made equipment does not appear to pose any severe logistic problems. It is foreseeable, however, that the utilization of certain types of applique kits and units may be required during some point in time in the early stages of the change.

The following comments apply to DCS data base, circuit layout cards, and plans of the DCA areas:

DCS Data Base: Trunk miles will have to be converted to kilometers. This should be no problem, except for trunks extending over 6,000 miles, which when converted, will be in excess of 10,000 kilometers. The present data field reserved in the DCS Data Base for this type of information is limited to four characters.

Circuit Layout Record Cards: Trunk miles will have to be converted to kilometers.

Plans: Weights and measures presently quoted in all DCS/DCA type of plans will have to be converted.

DEFENSE INTELLIGENCE AGENCY COST ESTIMATES

The cost for metrication would be negligible. Defense Intelligence Agency (DIA) monitors and manages but does not fund the Military Departments' intelligence activities. As a management and intelligence production agency, metric conversion would have no significant monetary impact. A monetary cost estimate for metrication would approximate one-tenth of one percent of the FY 70 DIA budget ($107,102,000) or a cost of approximately $100,000 over the assumed ten-year conversion period. The added costs would be derived from the purchase of new equipment or modification of present equipment, data base file revisions, and training of personnel.

We see no need for an increase in people, and an almost negligible increase in space. Personnel training and equipment conversion will require a budget increase of perhaps 0.1% during the transition. However, we anticipated that equipment development and procurement contract costs will increase as much as 25% in the first few years, gradually tapering to a 10% increase. Thus, the transition period will require an NSA budget increase of about 4% during each of the first four years. The increase will decline to 3% the fifth year, 2% the sixth, 1% the seventh, and 0.1% for the last three years.

APPENDIX D

Detailed Advantages and Disadvantages

Advantages Expected During Transition. The following advantages are those that are peculiar to the transition period. In addition, all of the long-term advantages would be felt in an increasing fashion as transition progresses.

There will be an opportunity to establish standards based on preferred metric sizes.

The need to convert to SI units will give industry and government an unprecedented opportunity to review, correct, and update their documents.

Disadvantages During Transition. During transition the natural problems which evolve with change will occur. Many will subside with familiarity with the particular change. The following are examples of anticipated problem areas:

The psychological resistance of personnel to change could present a formidable obstacle. Few personnel, even engineers and scientists who are well versed in metric units, have the intuitive understanding or "feel" for metric sizes that they have for inch-pound sizes.

Capabilities and readiness will be decreased during the transitional period due to confusion associated with having to operate systems/equipments built to either one measurement system or the other or both. This condition will persist until complete conversion is effected. Conversions should be scheduled by operating unit, so far as possible, rather than by availability of component equipments. Where mixed systems are used, procedures must be developed to minimize error and maintain proficiency. Exercises and drills in making the operationally required conversions must be made a part of the personnel readiness training.

A most significant difficulty will be training and indoctrination of personnel. This is extremely critical in many areas where incomplete indoctrination can have fatal consequences such as safety in operations. From a "training" point of view, the greatest disadvantages will occur during the early stages of transition and require the expenditure of resources (manpower, money, time, and materials) to achieve the same degree of proficiency in the use of metric weights and measures as is now possessed in the use of the inch-pound system. At least three broad categories of training can be identified. A familiarization training program will be presented to all employees through formal training. The second category will be an intensive formal program involving production as well as service group personnel, facility and weapon engineers, laboratory technicians, material personnel and quality assurance personnel. The third will be on-the-job training. The category of training will be based on individual job requirements.

Personnel working with both metric and customary tools and equipment with different measurements will contribute to increased errors.

Technical data will be an impact area because of the need to accommodate the metric system. All manuals, regulations, technical orders, monitors, readouts, meters, maps, blueprints, plans, plant-in-place records, drawings, and other publications and specifications will have to be inspected and changes made on an as required basis.

Within the R&D area, decisions to determine when and how to change over new systems will greatly affect both the cost and time to develop each project. It is anticipated that a development program that was initiated during the middle transition period, 1974-1978, will experience difficulties in both the cost and schedule areas. During this period, the designer will find it difficult to determine the optimum mix of metric and inch-pound specifications required to permit procurement of his design at the minimum cost. During the period 1977-1982, these factors will no doubt increase in complexity. The increasing

number of SI standards will present the designer with a constantly changing basis for his designs. He will encounter situations where items specified to an SI standard are not available. These problems will result in many design changes and deviations during the development. Significant additional design effort is anticipated for redesign of certain existing parts, components, and subassemblies that would have been suitable for use in a system design in inch-pound system, but are not suitable for use in a metrically designed system. An interface will have to be established and maintained by design personnel among designers, shops, and suppliers so that the designs developed can be produced by available machine tools and from stock materials whose specifications and availability will also be undergoing change.

The transportation of cargo is based on conventional measurements. Palletization, containerization, and standard loading systems are all interfaced and must be maintained compatible. Further, the air cargo operation directly interfaces with surface and sea systems and compatibility must also be maintained. Widespread adoption of the metric system will require metric orientation guides, guidance, and instructions for use of shipping and transport personnel. The movement of materials is controlled by the volume, shape, and weight of the item to be transported. Conversion tables and modified measuring equipment (scales, etc.) will be required. Rapid response containerized distribution envisions the interaction of containers, materials handling equipment, transportation equipment and documentation. Trends and efforts toward standardization of van type containers will require consideration of compatibility with carrier equipment and distribution methodology. A variety of specialized types of containers are already in existence. However, conversion of current or future containers to new dimensions to comply with a new metric system standard is not considered technically or economically justified at this time. For example, freight van containers are built in the United States to conform to standards adopted by the USASI (United States of America Standards Institute), with about seventy percent of the member bodies of the ISO (International Standards Organization) having approved the USASI standards.

Depot maintenance operations will require more time and material during the transition period. Field maintenance organizations must solve the problem of transporting the extra equipment and material which the metrication process will impose. The maintenance section of an armored cavalry squadron, for example, currently has a prescribed load list (PLL) of 466 line items. When the squadron goes to the field, the maintenance section must carry the PLL plus all of its other equipment and tools in organic transportation. This transport is already overcrowded and the addition of 25-50% more to the PLL due to dual part stockage and dual tool sets will further compound this problem.

There will be a need for dual common tools and special precautions will have to be taken to prevent mixing of common hardware and tools. It can be anticipated that there will be some increase in damage caused by maintenance technicians due to inadvertent mixing of inch and metric parts and tools. In some cases additional shop space will be required for maintaining equipment in both systems especially when separate metric and nonmetric operations must be maintained.

Metalworking equipment (machine tools) for the most part has a long life span. Some of the items in use today are over 35 years old and still operating. The Defense Industrial Plant Equipment Center reports that the DOD has 144,122 machine tools in the DIPEC inventory which had an original acquisition cost of approximately $2.4 billion. Studies indicate that modification of the inventory would cost approximately $115 million. Gauges, markings, and dials on 95 percent of this equipment are graduated in the inch-pound system. Inch-pound and metric machine tools are generally capable of producing

components dimensioned in either system of units provided the operator has the necessary measuring equipment. The major exceptions are screw threads, gears, and splines. Conversion of the feed mechanisms to enable a machine tool to be used under the metric system could be achieved in two ways. The first, and usually more expensive method would be to replace the feed screw and nut assemblies of the machine with units having metric pitch. The alternative method would be to replace or add to the inch-pound reading indicator one engraved in metric units.

There will be an increase in Federal Stock numbers due to dual part stockage. Estimates for this increase range from a peak of 18% to 50%. Parts interchangeability and shortages of metric material, particularly in the early conversion period, will be a problem. There will be some requirements for more storage space, and perhaps a need to separate common items.

Metrication will, in the early phases, result in considerable confusion when attempting to secure quotations for supply, services, and equipment. Additional management effort will be required specifically for planning and phasing the production and procurement of metric components. There will be some increase in acquisition and development time, primarily due to gathering metric information, and preparing drawings with metric or dual dimensions. Further, there will be a requirement for dual specifications, a need to update technical documentation and an increase in the number of engineering changes. The procurement of off-the-shelf bits and pieces poses a peculiar conversion problem.

The majority of the dollar costs previously discussed in the report under Sec IV A., Added Cost to Maintain Constant Mission Capability, will occur during this period. In addition to cost, time delays will also be encountered in the system acquisition area.

During the transition period, conversion to SI will result in a major increase in complexity of industrial readiness planning. Industrial readiness planning will have to be continuously updated as the conversion to SI proceeds. To maintain industrial readiness during periods of hostilities or other military commitments, plans will have to be developed so that production capability under the present system will not be lost until adequate capability is assured under the metric system.

Computer programs for data systems will have to be revised. For example, tactical data systems operating as an entity will require simultaneous conversion of all units if they are to retain their usefulness. Present gun and missile fire control computers are of the analog type, except for some very recent systems which are digital. Analog synchro data transmission systems are used with the analog computers. Sensors such as fire-control radars and optical rangefinders provide analog data readouts. All of these elements of the fire control systems (computers, transmission systems, and sensors) are calibrated in other than SI units. There is no simple and inexpensive way to convert analog fire control systems to SI units.

New equipment will be designed and constructed using SI units of measurement while other equipments which were designed and constructed using inch-pound units of measurement are still in service. This means that the DOD will be operating mixed equipment for an indefinite period. Under these circumstances, the possibility of maintenance errors will increase through greater exposure to unintentional use of improper tools, parts, instruments, and calibrations. It will be necessary to train maintenance personnel in the use of both measurement systems to counteract possible confusion and a greater possibility of error. Once the change to the metric system of measurements is accomplished, the international cross servicing and maintenance of systems will be less susceptible to error.

Installed and support equipment in operational systems may require modifications to maintain system compatibility during the conversion process.

Communications procedures pertaining to weather, navigation, and takeoff/landing instructions will have to be revised to accommodate the change.

Observations and weather reports will have to be changed to reflect metric measure for ceilings, visibilities, altitudes, and windspeeds.

Long-term Advantages.

The establishment of a worldwide standard of weights and measures will facilitate the interchange of ideas, technology, data, etc. Acceptance of the International System of Units (SI) will contribute to the establishment of a worldwide standard for measurements. This will allow elimination of multiple systems of units and will eliminate the necessity for the time-consuming conversion required to transfer from one system of units to another. Several of the advantages which will accrue to the DOD are listed below.

There will be the potential advantage of worldwide compatibility in every phase of operations.

Commonality of items and systems between U.S. and foreign nations will expedite repairs on inoperative equipment, thus providing possible support in areas where support is now nonexistent.

An increased potential for international standardization will result in the necessity to procure, handle, stock, distribute, operate, and maintain fewer systems/equipments and thus reduce the expenditure of resources.

Metrication will make our measurement system more compatible with that of our Allies worldwide. This will provide for easier and better interface between our weapons systems and those of our allies. Exchange of information will also be expedited by simplifying the understanding of all data including design, operations, and training.

Acceptance of the metric units will provide a simplicity not inherent in the inch-pound system or similar systems of units which do not have a base of 10. It will eliminate the current hybrid mix of units now used throughout the various technologies. There is only one definition and one name for each unit (in the inch-pound system, for example, there are different sized "ounces" and "pounds" depending upon whether Troy weight or Avoirdupois weight is being utilized); the units in other systems have a mixed relationship to each other (e.g., inches - feet - yards - rods - miles) but the SI units are related by factors of 10. As a result, complex conversion factors are not required for calculations. Calculations will be in the simplest form possible (e.g., no complex conversion factor will be needed to convert meters to millimeters, which is not the case, for example, in converting rods to inches and will be performed with ease and less error).

Favorable results from standardization on metric units of measurement can provide impetus for standardization of hardware.

Metrication will provide potential advantage in standardization and worldwide availability of standard packages, parts and equipment procured through the local purchase sources.

Metrication will reduce the total training time required to teach and indoctrinate mechanics, engineers, and others.

The chance for error in computations will be greatly reduced when the metric system is fully implemented. Compatibility will be achieved among range instrumentation, scientific measuring devices, and engineering units.

A general modernization and updating of individual plant equipment, ground equipment, and shop hand tools can be expected upon converting to the metric system.

Savings will be realized in automatic data processing time as a result of fewer conversions and simpler programming.

Long-term Disadvantages.

The completion of metrication will leave some long-term disadvantages. Those that will occur deal with long life items which will remain in inventory well after the programmed transition. These include:

There will be difficulty experienced in retaining material and manpower for the maintenance, modification or activation of existing long-life systems, equipments and facilities.

Dual (inch-pound and metric) ranges of material and support equipment will have to be maintained in inventory in varying quantities for a period approaching thirty years.

Due to smaller production runs, there will be an increasingly greater cost of material produced under the inch-pound system for the maintenance, modification or activation of systems, equipments and facilities.

There will be a continuing need for the training of personnel in the use of inch-pound systems.

There could be a forced obsolescence of productive, useful and otherwise satisfactory material.

There could be a loss of skilled manpower due to the inability to train existing skilled technicians to an equal degree of proficiency in the use of the metric system.

Prepositioned equipment may need conversion before being activated.

APPENDIX E

International Standards and Piece Parts

INTERNATIONAL STANDARDS

One of the most important consequences of a change to the metric system by the United States would be the effect of the change on international standards. International standards are now becoming one of the most potent factors in international trade. The highly industrialized nations of the world are modifying their national standards to be compatible with those developed by the International Organization for Standardization and the International Electrotechnical Commission. The developing countries are accepting many of these international standards, often without change, as their national standards and as the basis for purchasing goods from abroad.

Practically all standards involve measurements of one kind or another, so any major change in the system of measurements used in the standards is bound to have a major effect on the standards themselves. The introduction of SI units into engineering standards is only one facet of metrication. It is a step now being taken by national standardizing organizations and is not dependent on the entire country changing its measurement units. It is a necessary step in fostering the use of United States standards internationally. It is clear that the critical period is upon us and that international standards are and will move rapidly forward in this decade towards completion of the bulk of the work with or without us. Our choice is to withdraw and try to adjust later or participate now and influence things more toward our own desires.

PIECE PARTS

One of the greatest areas of impact would be conversion from the United States standard off-the-shelf bits and pieces to those of the metric system. If the U.S. decides to convert, the plan must establish exactly where we are going in this area. We must establish those DOD standard and industry standard bits and pieces we are going to redimension in the metric system and keep, and those which do not conveniently redimension in the metric system or would be an awkward size or shape in the metric assortment and hence must be abandoned. The problem closely related to any measuring system is industrial standardization within the system and the full benefit of a universal measuring system would not occur unless the industrial countries accept a set of universal standards such as those of an international standards organization.

The two systems of off-the-shelf items (e.g., screws, nuts, bolts) should not be mixed on any one weapon system component since it would greatly complicate logistics support and maintenance. Perhaps, a clean break should be made on those weapon system components which utilize metric off-the-shelf hardware. In converting the J-79 engine, the German engineers stuck strictly with the U.S. standard bit and piece hardware items.

As a result of current investigations, it is now believed that the metric standard off-the-shelf bit and piece hardware that would be used in a weapon system, is not superior in any way to that available under the U.S. system. For instance, it is not believed that metric bits and pieces would improve performance or increase reliability. Therefore, the only advantage to transitioning to some metric standard system of hardware would be to standardize to bit and piece hardware used by several countries. This, of course, would be of tremendous advantage within an organization such as NATO.

APPENDIX F

Legal Aspects

On 28 July 1866, the thirty-ninth Congress (Session 1, Chapter CCCI) approved "An Act to authorize the Use of the Metric System of Weights and Measures." This Act reads as follows:

"Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That from and after the passage of this act it shall be lawful throughout the United States of America to employ the weights and measures of the metric system; and no contract or dealing, or pleading in any court, shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system.

Sec. 2. And be it further enacted, That the tables in the schedule hereto annexed shall be recognized in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the United States, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used in computing, determining, and expressing in customary weights and measures the weights and measures of the metric system."

MEASURES OF LENGTH

METRIC DENOMINATIONS AND VALUES		EQUIVALENTS IN DENOMINATIONS IN USE
Myriameter	10,000 meters	6.2137 miles
Kilometer	1,000 meters	0.62137 miles, or 3280 feet and ten inches
Hectometer	100 meters	328 feet and 1 inch
Dekameter	10 meters	393.7 inches
Meter	1 meter	39.37 inches
Decimeter	$\frac{1}{10}$ of a meter	3.937 inches
Centimeter	$\frac{1}{100}$ of a meter	0.3937 inches
Millimeter	$\frac{1}{1000}$ of a meter	0.03937 inches

MEASURES OF SURFACE

METRIC DENOMINATIONS AND VALUES		EQUIVALENTS IN DENOMINATIONS IN USE
Hectare	10,000 square meters	2.471 acres
Are	100 square meters	119.6 square yards
Centare	1 square meter	1550 square inches

METRIC DENOMINATIONS AND VALUES OF CAPACITY & WEIGHTS AS EXPRESSED IN THE 1866 LAW ARE CONTINUED IN TABLES 1 & 2.

Table 1

MEASURE OF CAPACITY *

METRIC DENOMINATION AND VALUES			EQUIVALENTS IN DENOMINATIONS IN USE	
Names	Number of liters	Cubic Measure	Dry measure	Liquid or wine measure
Kiloliter, or stere	1,000	1 cubic meter	1.308 cubic yards	264.17 gallons
Hectoliter,	100	$\frac{1}{10}$ of a cubic meter	2 bushels and 3.35 pecks	26.417 gallons
Dekaliter	10	10 cubic decimeters	9.08 quarts	2.6417 gallons
Liter	1	1 cubic decimeter	0.908 quarts	1.0567 quarts
Deciliter	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic decimeter	6.1022 cubic inches	0.845 gills
Centiliter	$\frac{1}{100}$	10 cubic centimeters	0.6102 cubic inches	0.338 fluid ounces
Milliliter	$\frac{1}{1000}$	1 cubic centimeter	0.061 cubic inches	0.27 fluid drams

* As expressed in the 1866 Law.

Table 2

WEIGHTS *

METRIC DENOMINATIONS AND VALUES			EQUIVALENTS IN DENOMINATIONS IN USE
Names	Number of grams	Weight of what quantity of water at maximum density	Avoirdupois weight
Miller or Tonneau	1,000,000	1 cubic meter	2204.6 pounds
Quintal	100,000	1 hectoliter	220.46 pounds
Myriagram	10,000	10 liters	22.046 pounds
Kilogram or kilo	1,000	1 liter	2.2046 pounds
Hectogram	100	1 deciliter	3.5274 ounces
Dekagram	10	10 cubic centimeters	0.3527 ounces
Gram	1	1 cubic centimeter	15.432 grains
Decigram	$\frac{1}{10}$	$\frac{1}{10}$ of a cubic centimeter	1.5432 grains
Centigram	$\frac{1}{100}$	10 cubic millimeters	0.1543 grains
Milligram	$\frac{1}{1000}$	1 cubic millimeter	0.0154 grains

* As expressed in the 1866 Law.

The 1866 law and any other enactments which mention inch-pound units of measurement, should be reviewed by the National Bureau of Standards to determine the need for updating.

It is envisioned that any legal problems would be of the "constructive change theory" type. Under this concept, contractors may be expected to request price increases due to the metrication schedule and defective specifications wherein the difficulty of converting from inch-pound units of measurement into exact equivalents in the metric system of measurement would probably cause manufacturing problems, particularly in tolerances. Contracts would be let on design disclosures which were improperly converted, making legal action common for companies to claim government fault. Government material furnished under a contract would not fit the contractor's machine tools causing added expense and dissatisfaction, both by the government and contractor alike. If requirements for metrication were so imposed as to apply to existing contracts specifying inch-pound measurements, some kind of blanket change terminology would presumably have to be devised (e.g., "All dimensions stated in the contract drawings in terms of inches are hereby changed to the nearest equivalent measurement in centimeters, carried out to the nth decimal place"). The contract actions, both the boiler plate section of government contracts and the quotes contractors submit as a response would contain new statements disavowing responsibility for problems stemming from the introduction of SI units. In many cases the contractor would be placed at a disadvantage. The government, on the other hand, could also find itself in a comparable position. Legal action would be much more common than now experienced.

Armed Service Procurement Regulations (ASPR) should be changed to accommodate a possible change to the metric system of measurements.

One clause that would require change covers "Guaranteed Maximum Shipping Weights and Dimensions" (ASPR 2-201(a)B(X)), which includes a requirement to show weight in pounds and dimensions of containers in inches.

A patent grant gives to its owner the right to exclude others from practicing an inventive concept not restricted to a particular dimension or quality. Although the patent system is presently undergoing significant change, this precept is not expected to change. Each patent must include a complete technical disclosure of a preferred embodiment of the inventive concept so that one ordinarily skilled in the art may construct and practice the invention, but the disclosure need not include specific dimensions or quantities unless such dimensional or quantitative limitations are critical to practicing the concept. Where such critical limitations are recited in the patent claims in inch-pound units, the patent law doctrines of substantiality and equivalency will enable the claims to be construed in metric units. Metric units have traditionally been used in chemical patents and these doctrines have extended these patents against infringing products or processes where the critical limitations are characterized in nonmetric units. Accordingly, it is not foreseeable that any novel legal questions would arise in the field of patent law through metrication. ASPR IX, Part 1, describes mandatory patent clauses for research and development contracts awarded by DOD procuring activities. These clauses establish criteria for determining the relative patent rights of the Government and the contractor in inventories arising out of such contracts, and they do not alter the basic precept that patents are granted on inventive concepts and are not restricted to specified dimensional or quantitative embodiments. Accordingly, no changes in these clauses appear necessary at this time for metrication.

Data rights, often called proprietary rights in data, involve a very complex area in the law of trade secrets. The data may describe a secret process of manufacture or characteristics of an end item which cannot be determined by inspection or analysis.

ASPR IX, Part 2, deals with this area of the law insofar as Government acquisition of rights in data. The regulation contains no specific provisions as might relate to metrication, but there are provisions which might be so construed. These areas should be reviewed to assure they delineate more particularly the respective rights of the Government and contractors in data converted pursuant to a metrication program. For example, the rights of the Government should be clarified as to data (converted to SI system at private expense) pertaining to items developed at Government expense, and as to data (converted to the SI system at Government expense) pertaining to items developed at private expense.

A copyright grants authors or owners an exclusive right to publish certain types of works including technical books and drawings. The copyright extends only to the manner of presentation of information or concepts, and not to the information or concepts themselves. Metrication may raise questions whether or not a copyrighted work converted from inch-pound units to the SI system would result in a copyright infringement. The ASPR data clause provides for the Government acquiring license to any copyrighted material specified to be delivered under contract. It appears that this provision and others should be studied in relation to court decisions to determine whether or not further clarification is required.

Presumably the primary responsibility for drafting the laws necessary for a change to the use of metric measurements would be in the Department of Commerce. After such law has been drafted, the DOD should have an opportunity to review and comment, prior to its enactment, from the standpoint of need for exception clauses. It would appear that sufficient sanctions already are provided under legislation and regulation affecting personnel and their conduct in relation to orders or directives to effect such compliance as may be directed. In addition, the attractiveness of any contract award, at a price satisfactory to the bidder, would appear likely to gain us contractual agreements to employ the metric system on goods ordered as a necessary incident of compliance with specifications expressed in metric terms.

APPENDIX G

Current Usage of Metric System

The metric system is already in use in many fields of research, i.e., material sciences, physics, chemistry, earth sciences, biological and medical sciences. In the more scientifically oriented aspects of research, the use of the metric system is virtually complete. Both the metric and the inch-pound system of weights and measures are used extensively in the nuclear sciences and related engineering. Generally, all scientific measurements in oceanography (other than depth and tide) are made using metric units.

The metric system is the present standard of electrical measurement. The standards covering the expression of voltage, resistance, current, magnetics, capacitance, inductance, quantities of power and frequency are directly traceable to SI units. Important SI units which are the common United States units are the watt, coulomb, joule, ampere, farad, henry, weber and ohm. Pharmaceuticals, laboratory equipment, surgical measurements, calibration devices, optical instruments, photographic equipments and certain gunfire control systems are produced in the SI system. Mechanical items now commercially available in SI measurements include spark plugs and ball bearings.

For international exchange of weather information, Air Weather Service uses the metric system for observing, recording, and processing of some environmental parameters; specifically, visibility, temperature, and dew point.

The metric system is quite extensively used in the medical service at the present time. Clinical laboratories have been and are fully utilizing the metric system of weights and measures in all their technical procedures. Applicable directives, laboratory texts, etc., are printed to correspond with this actual metric system usage. Hospital pharmacies uitlize the metric system exclusively in the manufacturing and administration of drugs (includes prescription writing). Under nursing services, the metric system is used in the administration of medication (oral, intramuscular, intravenous, anesthesia) in DOD medical facilities. Measures of input and output of patients are completed in the metric system. The dental service is already fully using the metric system in the treatment of animals and operation of their zoonosis control clinic.

The metric system has limited application in the munitions field, i.e., 20mm cannon and 7.62mm machine gun. Explosive ordnance disposal publication lists explosive weight in grams/kilograms. Munitions components (fuses, delay elements, boosters, etc.) have their explosive weight measured in grams. The kilogram is the unit of weight measurement for radioactive materials.

Field Armies make only limited use of metric measurement or hardware, although tactical operations are specified in metric units. Army Regulation 310-3 expressly states that the metric system will be used to express linear distances in matters pertaining to tactical and related administrative support operations, e.g., air and road distances, rates of movement, etc.

The metric system is currently used in facilities construction in most overseas bases.

Weights and measures of shipments to foreign countries are converted to the metric system so that they can be handled by foreign transportation contractors.

Common areas of metric system usage are photography, electrical/electronic, medical photometry, holography, and laboratory equipment. Geodetic measurements (including satellite geodesy) use metric units. Metric units are also utilized to some degree in the areas of electromagnetic radiation, propagation, sensing, infrared, ranging devices, signal processing and interpretation, photographic instrumentation, close air support operations and mapping.

APPENDIX H

Customary Standards that should be Retained

Inch-pound standards that have wide international acceptance should be retained until suitable metric standards are developed and accepted. An example of this type of standard would be the unified screw thread standard for fasteners. The ABC (American, British, Canadian) standardization of the Unified Screw Thread System has established, throughout the world, a thoroughly documented, efficient system superior to any other screw thread system in existence today. The ABC Unified Screw Thread System is recognized as an international standard in metric countries. There is no single metric thread standard in common usage within all of the metric countries at the present time. Standards/specifications for these items should not be recommended for conversion to SI units at this time. Other standards have universal acceptance and should not be changed. Tires and wheels produced in metric countries, as well as in the United States, are manufactured and sold in inch sizes. Similarly, the DOD procures an enormous amount of petroleum products (oils, greases, gasolines, aviation fuels, etc.) from United States firms that have affiliates in almost every oil producing country today. The standards/specifications for these products are accepted and used throughout the metric countries. They should be retained and not proposed for conversion to SI units at the present time. Many military standards will remain unchanged since they will be required to support existing equipment. Special units of measure such as artillery mil for fire control and wind direction and sieve dimensions for propellant and explosive manufacture should also remain unchanged. A thorough review of the Department of Defense Index of Specifications and Standards would be required to list all military standards to be retained.

In addition to standards, there are nonmetric units of measure which have worldwide acceptance. It seems highly improbable that any nation using SI units would abandon such units as the hour, day, year, nautical mile, degrees, minute of arc, etc. For example, the recommended SI unit of angular measurement (radian) provides no significant computational advantage over using degrees. Further, air traffic control and navigation instrumentation (glide slope, bearing, etc.) would be needlessly complicated and confused by converting to radians as a standard for angular measurement. Within navigation, another unit to be retained is the nautical mile. The recommended SI unit of distance (kilometers) is not consistent with the divisions of latitude and longitude, the basis for all navigation. The nautical mile has been devised to be consistent with a minute of latitude. Navigation could be needlessly complicated if the measurement of nautical miles was replaced with kilometers. If the knot and nautical mile are retained, the entire system of navigation as used internationally could be preserved.

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This publication reports the results of a Department of Defense study, conducted pursuant to the U.S. Metric Study Act, to determine and evaluate the advantages and disadvantages, including impact on operational capability, that would attend adoption of the International System of units of weights and measures (otherwise known as the Modernized Metric System) for use in the Department (DoD). The report includes estimates for each of the major components of the DoD of the costs of a transition to metric system usage. In addition to discussing the specific advantages and disadvantages that would be expected within the Department, the report describes the dependence of the DoD on the National Industrial Base, and discusses how this interaction would be involved in a national metrication effort.

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